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MARITIME OBSERVATION SATELLITE PROPOSAL

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JPRS 83101

21 March 1983

JAPAN REPORT

No. 168

MARITIME OBSERVATION SATELLITE PROPOSAL

Tokyo NEC MOS-1 in Japanese Oct 79 pp 2-27

[Text] This booklet contains the outline of a proposal by Nippon Electric Company [NEC] on the Maritime Observation Satellite No 1 (MOS-1), which was planned by the National Space Development Agency.

The main features of our proposal are listed below.

- We have adopted the bias momentum method, which is based on our past achievement, is reliable, and works very well.

- We propose module construction, which is expandable for future work and easy to integrate.

- Our development work will be based on independent, domestic technology that has grown from local fabrication of many satellites.

MOS-1 will be the first Japanese satellite for observation of the earth. It will serve as a part of the development of the earth observation system, which will contribute to the effective use of our resources and the preservation of our environment. In order to observe maritime phenomena and to establish technology that is common to earth observation satellites, MOS-1 is intended to fulfill the following missions:

- To observe the chromaticity and temperatures of ocean surfaces by a radiometer for visible and near infrared radiation (MESSR), a radiometer for visible and thermal infrared radiation (VTIR), and a microwave radiometer (MSR).

- To learn operating techniques for solar synchronous satellites.

- To learn operating techniques for earth observation satellites.

- To carry out basic experiments in position determination by using a data collection system.

- To establish technology for domestic production of three-axes satellites.

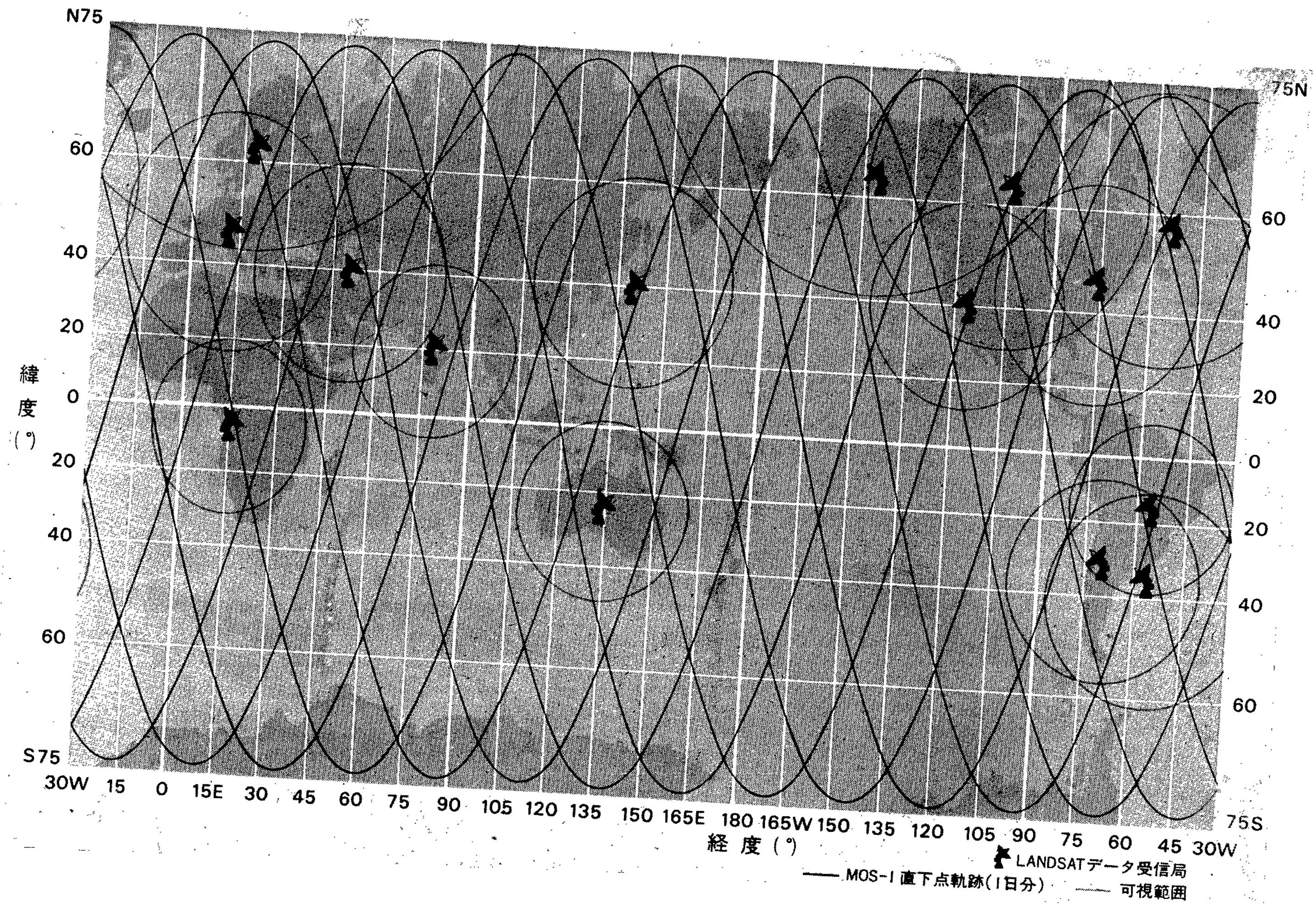
Based on our achievements and experience as the integrator of many domestically produced satellites, NEC has been accumulating technology for three-axes satellites from our own research and development. We have also been developing the MESSR, which is an instrument for the major mission of MOS-1. The development of MOS-1 will be based on these achievements and it will follow the basic policies listed below:

- To utilize locally developed technology based on our achievements and experience as the integrator of more than 10 domestically produced satellites.

- To provide flexible on-board equipment to carry out the satellite's mission, and to assure expanded applications for future satellites.

- To obtain technical support from foreign partners in order to assure the completion of the mission and to minimize risks in development.

Contents [Original page number]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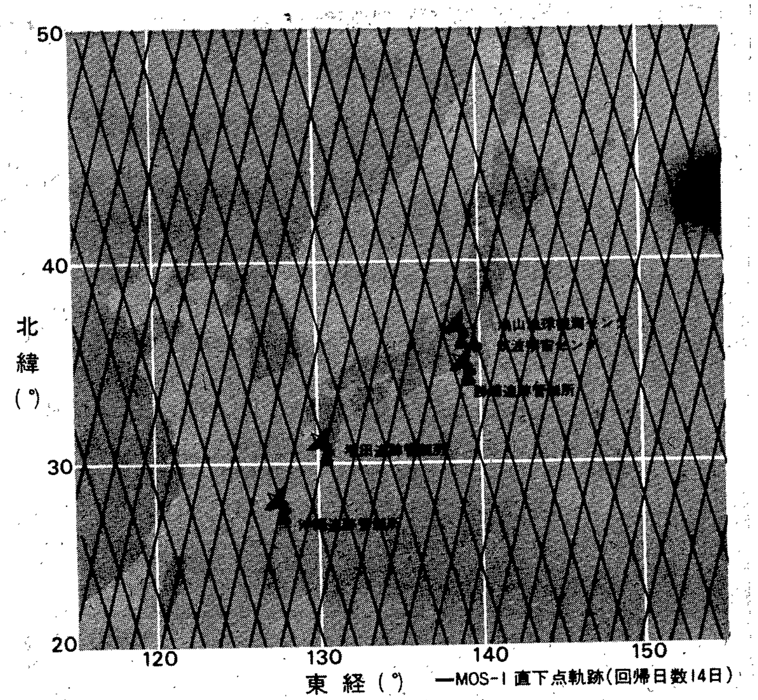

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The MOS-1 comprehensive system consists of the MOS-1 satellite, which circles on a quasi-recurring, solar synchronous orbit at an altitude of 913 km, data receiving stations that receive and utilize observation data, and tracking and control stations that launch, track, and control the satellite. The data transmitted from MOS-1 can be received not only by Japan but also by foreign data receiving stations.

Key:
(1) Latitude
(2) Longitude
(3) Terrestrial projection of MOS-1 orbit (one day)
(4) Landsat data receiving stations
(5) Visible range
(6) Northern latitude
(7) Eastern longitude
(8) Terrestrial projection of MOS-1 orbit recurs every 14 days)
(9) Hatoyama earth observation center
(10) Tsukuba earth observation center
(11) Katsuura tracking control center
(12) Masuda " " "
(13) Okinawa " " "

Satellite Mission

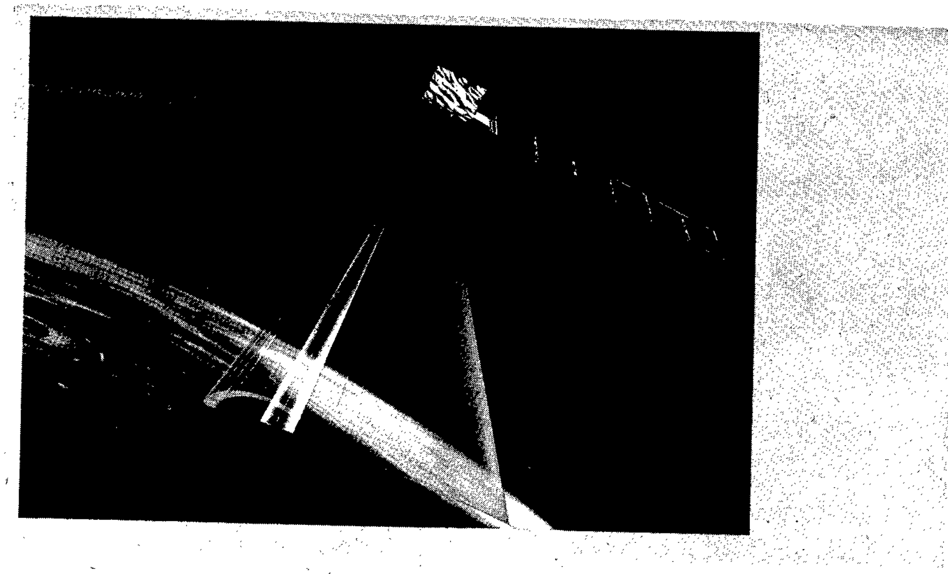
- Oceanic observation by equipment → on board.

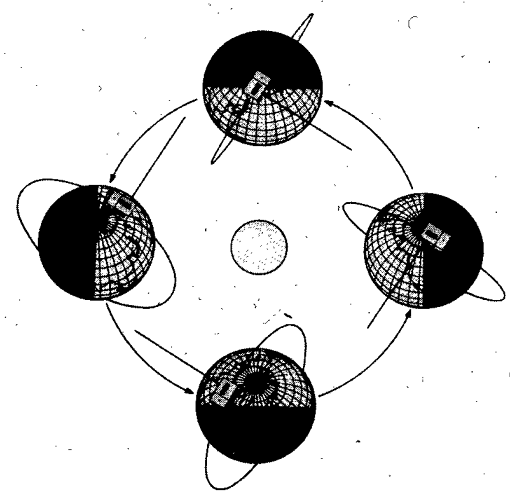
- The data observed by MESSR and VTIR are sent to the ground by an 8.4 GHz transmitter. The instruments will be used mainly to observe pollution of the ocean surface, ocean color, sea ice, plant distribution, temperature distribution in the ocean surface, and the distribution of cloud and water vapor.

- The data observed by MSR will be transmitted by USB and telemetry data. The data will be used to observe the distribution of water vapor in the atmosphere and sea and drifting ice.

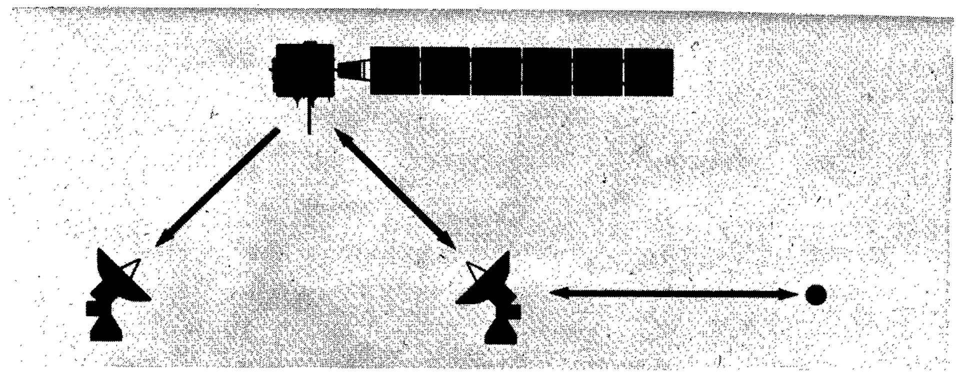
- To learn how to operate a solar → synchronous satellite.

The satellite's attitude is arrested immediately after it is separated from its launcher by checking the initial conditions of the satellite. These controls and commands to extend the solar cell paddle will be handled by the Tsukuba Space Center through down range stations in South America. The maintenance of the solar synchronous orbit (the calculation of errors in orbit and attitude and their correction operations) and the operation of the satellite (surveillance of satellite conditions and control manipulations) will also be carried out by the Tsukuba Space Center through tracking and control stations in Okinawa, Katsuura and Masuda.



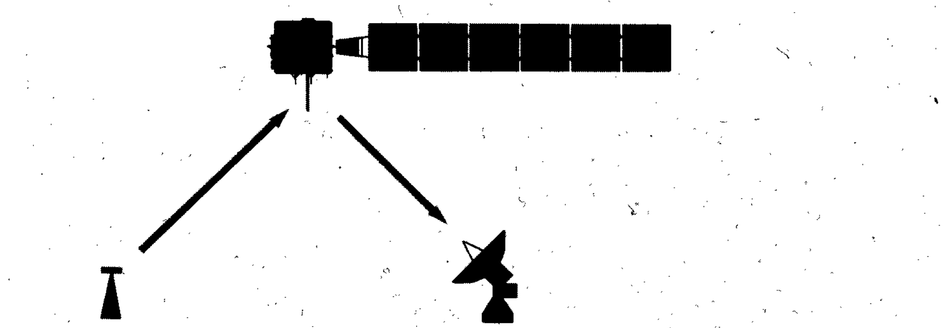


- To learn how to operate an earth observation satellite.



The observation data will be received mainly by the Earth Observation Center and some overseas data receiving stations. The Earth Observation Center will operate the instruments on board by exchanging information with the Tsukuba Space Center.

- To carry out basic experiments, such as position determination, using DCS.



By using relays for the data collection system (DCS), basic experiments in position determination for research and rescue operations will be carried out.

Satellite Configuration and Major Data

To carry out maritime observation, MOS-1 will be launched in the winter of 1984 from the Tanegashima Space Center by an N-II rocket launcher. The satellite will be put into a solar synchronous orbit of altitude 913 km and inclination 99.1°. The weight of the satellite when it is launched will be about 730 kg.

In this satellite, we have adopted a module construction that has high integration efficiency and can be easily expanded to other tasks. The satellite consists of two rectangular parallellepiped modules, i.e., a bus module and a mission module. Observational instruments and communication antennae are located on the side with the largest area with sufficient fields of vision.

The interface adaptor of the rocket is located at the bottom of the bus module, and the scan wheel assembly is attached on one side. Important instruments such as the attitude orbit control system, the gas jet system, the power supply system, and the telemetry/command system are mounted inside this module.

MESSR, the high speed data transmission section, VTIR, MSR, and the antenna system are mounted on the mission module. The solar cell paddle is also mounted on this module, and it is arranged to optimize the generated power according to the tasks to be performed. The generating capacity of MOS-1 toward the end of its useful life will be 590 watts.

Special features

- The solar cell paddle is built to form one sheet in order to secure the greatest field of vision for the instruments on board.

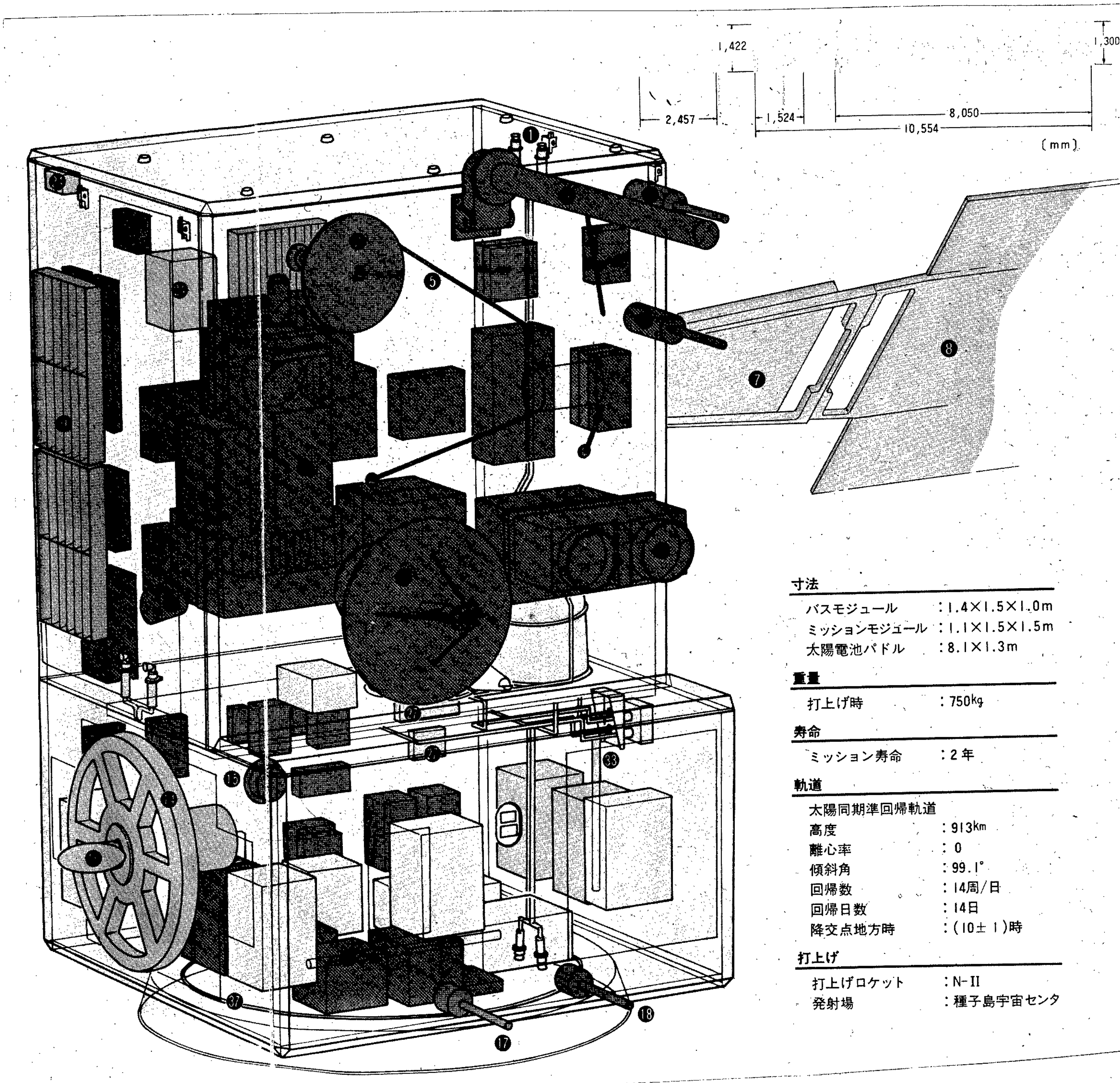
- By using the module construction, integration has been made easy and instruments can be expanded for other tasks.

- The bias momentum method has been adopted to improve its reliability and usefulness.

- Thermal control has been made safe by using both passive and active thermal control methods.

- The existing facilities are used effectively by using the same telemetry/command method as the one that is used for ETS-III [satellite]. Stored command and stored data methods are also used, and the satellite can be operated from Japan alone.

- The adopted configuration has sufficient spare electric power, and observed data can be sent to foreign data receiving stations.



寸法

バスモジュール	: 1.4×1.5×1.0m
ミッションモジュール	: 1.1×1.5×1.5m
太陽電池パドル	: 8.1×1.3m

重量

打上げ時	: 750kg

寿命

ミッション寿命	: 2年

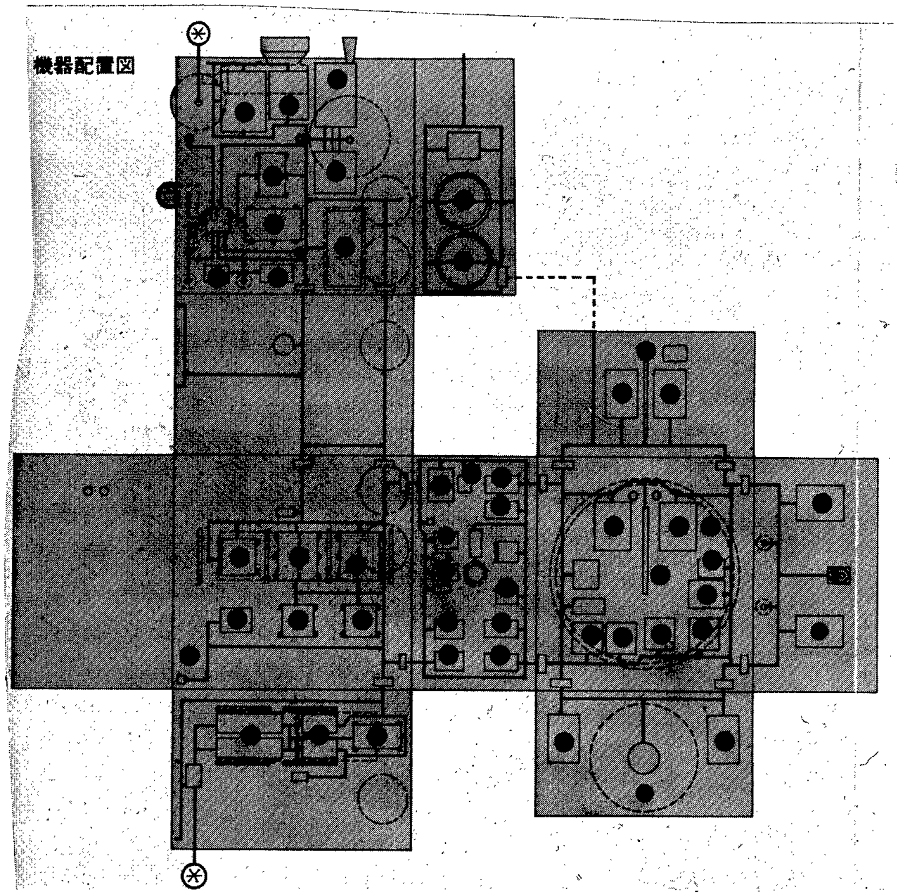
軌道

太陽同期準回帰軌道	
高度	: 913km
離心率	: 0
傾斜角	: 99.1°
回帰数	: 14周/日
回帰日数	: 14日
降交点地方時	: (10±1)時

打上げ

打上げロケット	: N-II
発射場	: 種子島宇宙センタ

Arrangement of Equipment



Key:

1. Thrusters
2. X-band antenna
3. DCS/SAR up-link antenna
4. USB antenna
5. VHF antenna
6. DCS/SAR down-link antenna
7. Shunt dissipater
8. Solar cell panel
9. Thermal louver
10. Visible, thermal infrared radiometer (VTIR)
11. Sky horn
12. Microwave radiometer (MSR)
13. Visible, near infrared radiometer (MESSR)
14. Momentum wheel
15. S-band transition antenna
16. Earth sensor
17. S-band up-link antenna
18. S-band down-link antenna
19. MSR signal processing and driving sections
20. MESSR and its controllers
21. Propellant tanks
22. DCS/SAR relays
23. VTIR signal processing section
24. Terrestrial magnetism sensor and electronic equipment to process the data
25. MESSR signal processing section
26. High speed data transmission section
27. Sun sensors and electronic equipment to process the data
28. VHF receivers
29. VHF transmitters
30. S-band receivers
31. Signal synthesizing circuit
32. S-band transmitters
33. Magnetic momentum control coil
34. Electronic equipment for attitude orbit control
35. Magnetic attitude control coil
36. Boost converters
37. Nutation damper
38. Data recorders
39. Telemetry encoders
40. Command decoders
41. Power supply control unit
42. Batteries

Size

Bus module	1.4 x 1.5 x 1.0 m
Mission module	1.1 x 1.5 x 1.5 m
Solar cell paddle	8.1 x 1.3 m

Weight

Launch weight	750 kg

Lifetime

Mission lifetime	2 years

Orbit

Solar synchronous, quasirecurring orbit

Altitude	913 km
Eccentricity	0
Inclination	99.1°
Number of revolutions	14 revolutions/day
Recurrency period	14 days
Local time at the descending node	10±1 o'clock

Launching

Launcher	N-II
Launch site	Tanegashima Space Center

Attitude orbit control system

Three-axes control method	Bias momentum
Attitude control precision	Pitch/roll ±0.2° Yaw ±0.7°
Drift rate	Pitch/roll ±0.01°/second Yaw ±0.02°/second
Momentum wheel	100 Nms
Magnetic attitude control coil	50 ATm^2
Magnetic momentum control coil	20 ATm^2
Passive nutation damper	
Sensors	Conical scanning earth sensor Sun sensor Terrestrial magnetism sensor

Gas jet system

Orbit control thrusts	1 newton x 6
Propellant	Hydrazine 19.6 kg
Number of tanks	2

Power supply system/solar cell paddle system

Solar cell paddle	
Panel driving method	One-axis clock control method
Panel area	10 m^2
Solar cells	(2 cm x 2 cm) 21,996 cells
Glass cover	0.3 mm thick
Power generation	BOL 670 W; EOL 590 W
Charge regulator type power supply	
Bus voltage	29V
Batteries	NiCd 15 AH x 3
Satellite power consumption	519 W (148 W for bus equipment, 371 W for mission equipment)

Airframe System

Modular bus mission equipment

Single sheet panel (folded six times)

Size	
Bus module	1.4 x 1.5 x 1.0 m
Mission module	1.1 x 1.5 x 1.5 m
Solar cell panels	8.1 x 1.3 m
Weight	
Total	About 750 kg
Bus equipment	470 kg
Mission equipment	212 kg
Propellant	20 kg
Margin	49 kg

Thermal control system

Active thermal control	Thermal louvers, heaters, bimetals
Passive thermal control	Radiators, thermal blankets, condensers

Communication system/antenna system

VHF	Telemetry Command	136 MHz 148 MHz	Monopole antenna x 4
UHF	DCS/SAR up	406 MHz	Quadrifilar helical antenna x 1
L-band	DCS/SAR down	1543 MHz	Quadrifilar helical antenna x 1
S-band	Telemetry R & RR	1.7 GHz	Quadrifilar helical antenna x 2 Spiral antenna (for transition)x1
	Command R & RR	2.1 GHz	
	R & RR	2.1 GHz	
USB	Telemetry MSR	2.2 GHz	Quadrifilar helical antenna x 1
X-band	MESSR, VTIR	8.4 GHz	Turnstyle antenna x 1

Telemetry/command system

Data stored during the invisible period and high speed playback during the visible period

Stored commands

Telemetry encoder

Bit rate	1,024 bps
Number of entry	About 480

Command decoder

Bit rate	128 bps
Number of entry	Maximum 252 (real time) Maximum 16 (stored)

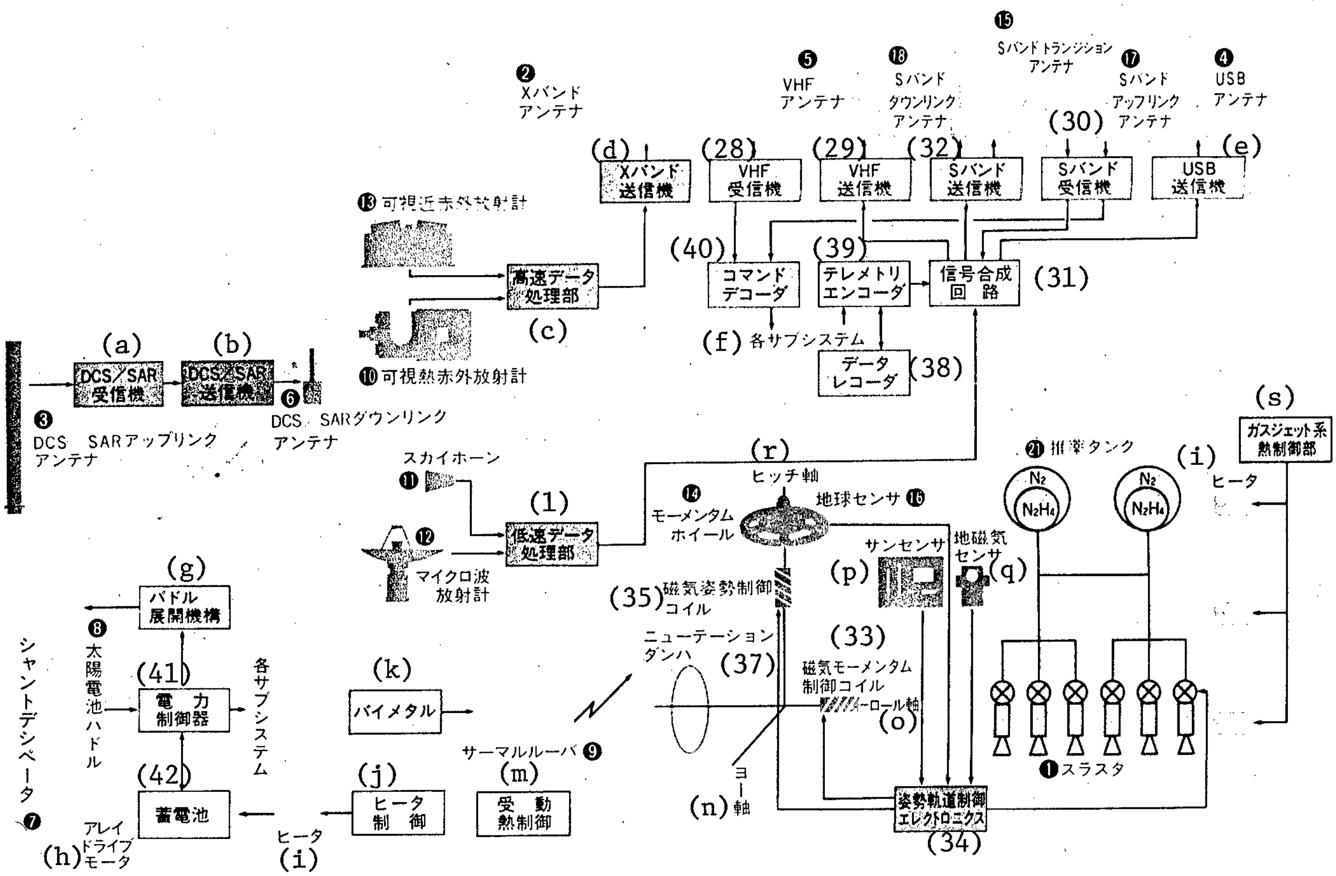
Data recorder

Input channel	1 channel (2 tracks)
Bit rate	1,024 bps (recording) 26,624 (playback)
Playback/record ratio	26/1
Recording time	Minimum 105 minutes
Playback time	Minimum 4 minutes

Mission equipment

MESSR	Band	1	0.5 - 0.6 μm
		2	0.6 - 0.7 μm
		3	0.7 - 0.8 μm
		4	0.8 - 1.1 μm
VTIR	Band	1	0.5 - 0.7 μm
		2	6.0 - 7.0 μm
		3	10.5 - 11.5 μm
		4	11.5 - 12.5 μm
MSR	Band	1	23 GHz
		2	31 GHz
DCS/SAR relay (DCS/SAR)	Up	406 MHz	
	Down	1,543 MHz	

System functions



Key:
(a) DCS/SAR receiver
(b) DCS/SAR transmitter
(c) High speed data processing section
(d) X-band transmitter
(e) USB transmitter
(f) Each subsystem
(g) Paddle extension mechanism
(h) Array drive motor
(i) Heater
(j) Heater control
(k) Bimetal
(l) Low speed data processing section
(m) Passive thermal control
(n) Yaw axis
(o) Roll axis
(p) Sun sensor
(q) Terrestrial magnetism sensor
(r) Pitch axis
(s) Gas jet system, thermal control section

[key continued]

[continuation of key]

1. Thrusters
2. X-band antenna
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42. Batteries

Table. Allocation of Weight, Electric Power and Reliability

	Weight allocation (kg)	Electric power allocation (watt)	Reliability allocation
Attitude orbit control system	50.7	14.3*1	0.8971
Telemetry/command system	32.0	32.1	0.9725*8
Communication system	20.1	30.6*2	0.9725
Antenna system	10.7	--	0.9938
Power supply system	94.8*3	20.0*4	0.9545
Solar cell paddle system	57.4*5	13.0	0.9399
Gas jet system	18.9	16.0*6	0.9516
Airframe system	120.0	--	0.9877
Thermal control system	20.0	22.0*7	0.9846
Mechanical and electrical instrumentation	45.0	--	(Included in the frame)
Bus instruments	469.6	148.0	0.700*8
MESSR	134.6	200.2	
VTIR	20.0	35.0	
MSR	54.0	120.0	
DCS/SAR relay	3.3	16.0	
Mission instruments	211.9	371.2	0.794
Satellite dry weight	681.5	371.2	
Propellant	19.6	--	
Margin	48.9	--	
Satellite total	750.0	519.2	0.5*8

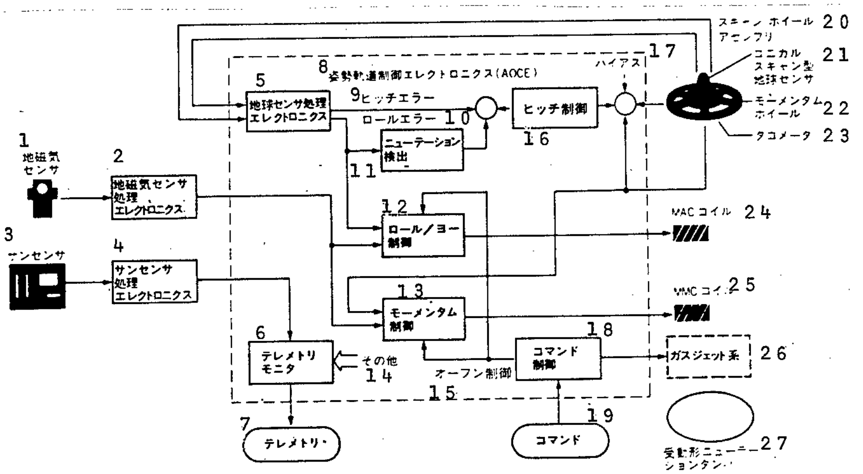
*1: Increases by 1.0 watt during roll/yaw control, and by 1.3 watts during unloading.
*2: Increases by 6 watts when VHF TX is turned on.
*3: Includes the weight of solar cells.
*4: Increases by a maximum of 83.8 watts when the boost converter is used.
*5: Does not include the weight of solar cells.
*6: Increases by 6 watts when a heater is used, and by 9.8 watts when a thruster is blasting.
*7: When a heater is on for orbit [control] only, while mission instruments are turned off.
*8: Excludes the data recorder (allocation 0.9).

Attitude Orbit Control System

The bias momentum method is used for the attitude orbit control system. The roll/yaw attitude and pitch control are maintained by a momentum wheel. The unloading and the roll/yaw control of the momentum wheel are controlled by a magnetic control method. Nutation of the satellite after its separation [from the launcher] is removed by a passive nutation damper, and nutation during the orbital operation is removed by an active nutation control. All attitude controls are carried out on board [i.e., not by command from the ground].

- Notable design characteristics

- Reliability and operability are secured by using the bias momentum method.
- Reliability and durability are secured by using a magnetic torquer.
- Long frequency nutation is removed by an active nutation damper.
- Operations are simplified through on-board processing.



Key:

1. Terrestrial magnetism sensor
2. Electronic equipment for processing the terrestrial magnetism sensor
3. Sun sensors
4. Electronic equipment for processing sun sensors
5. Electronic equipment for processing the earth sensor
6. Telemetry monitor
7. Telemetry
8. Attitude orbit control electronic equipment (AOCE)
9. Pitch error
10. Roll error
11. Detection of nutation
12. Roll/yaw control
13. Momentum control
14. Others
15. Often [transliteration uncertain] control
16. Pitch control
17. Bias
18. Command control
19. Command
20. Scan wheel assembly
21. Conical scan type earth sensor
22. Momentum wheel
23. Tachometer
24. MAC coil
25. MMC coil
26. Gas jet system
27. Passive nutation damper

Major Performance Data for the Attitude Orbit Control System

Attitude control precision	Pitch/roll ±0.2°, yaw ±0.7°
Attitude drift rate	Pitch/roll ±0.01°/sec, yaw ±0.02°/sec
Orbit maintenance precision	Altitude 913 km ± 390 m
Orbit control capability	Velocity correction to correct [orbit] insertion errors: In-plane control 14.2 m/sec Out-of-plane control 12.9 m/sec Velocity correction to maintain fundamental orbit: In-plane control 10.2 m/sec

Sun sensors

Type : Digital
Resolution : 1/256°
Precision : 1'
Field of vision : 64° x 64°

Terrestrial magnetism sensor

Type : Flux gate
Measurement range : ±50,000γ (all three gates)
Precision : Less than ±500γ

Momentum wheel

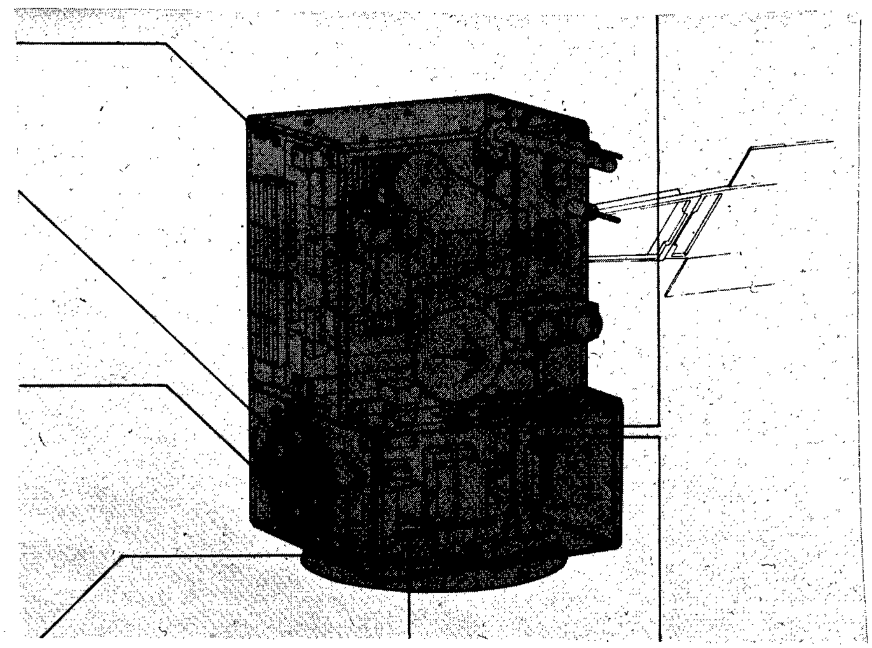
Moment : 100 Nms
Control torque : 0.66 Nms
Rotation rate : 750 rpm ±10 percent
Friction torque : 0.06 Nm

Earth sensor

Type : Conical scan (mounted on the momentum wheel)
Revolution rate : 750 rpm ± 10 percent
Precision : Pitch ±0.14°, roll ±0.09°
Measurement wavelength : 14 - 16 μm

Passive nutation damper

Inner diameter of tube : 30 mmϕ
Center diameter of tube: 1,100 mmϕ
Sealed liquid : Silicon oil (cst)
Nutation damping time constant : 2.3 hours



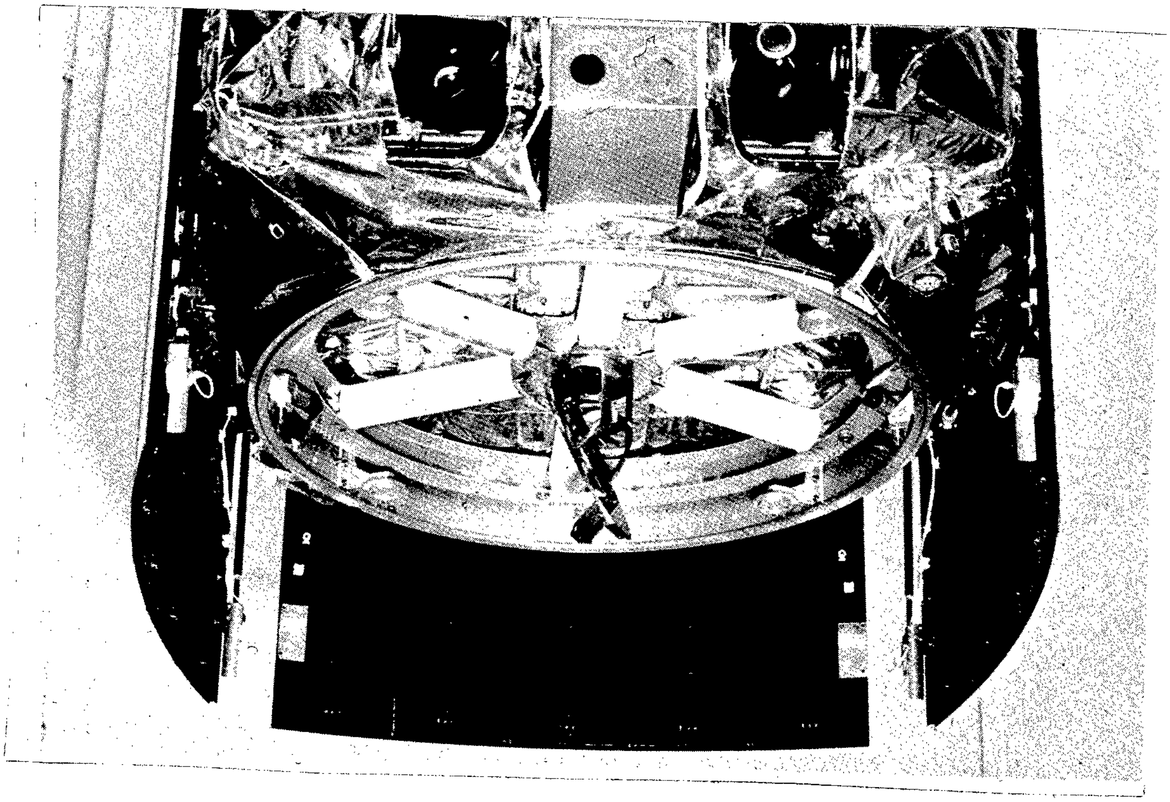
Magnetic attitude control coil

Maximum rated magnetic moment: 50 ATm^2
Shape : 64cmx2.6cmϕ (constant-current drive, duplex winding coil with core)

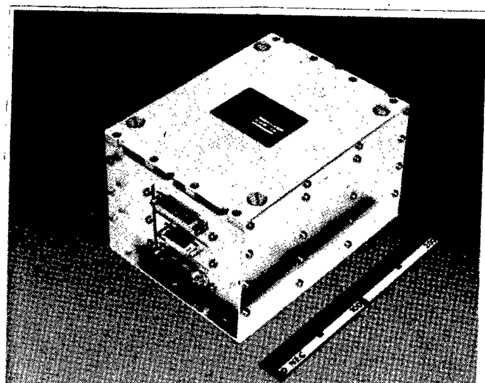
Magnetic momentum control coil

Maximum rated magnetic moment: 20 ATm^2
Shape : 49cmx1.9cmϕ (constant-current drive, duplex winding coil with core)

[Attitude Orbit Control System]

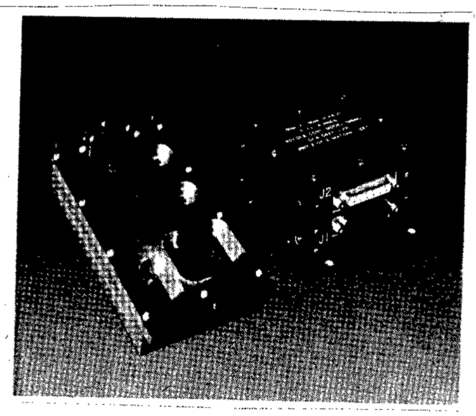


ITOS scan wheel assembly

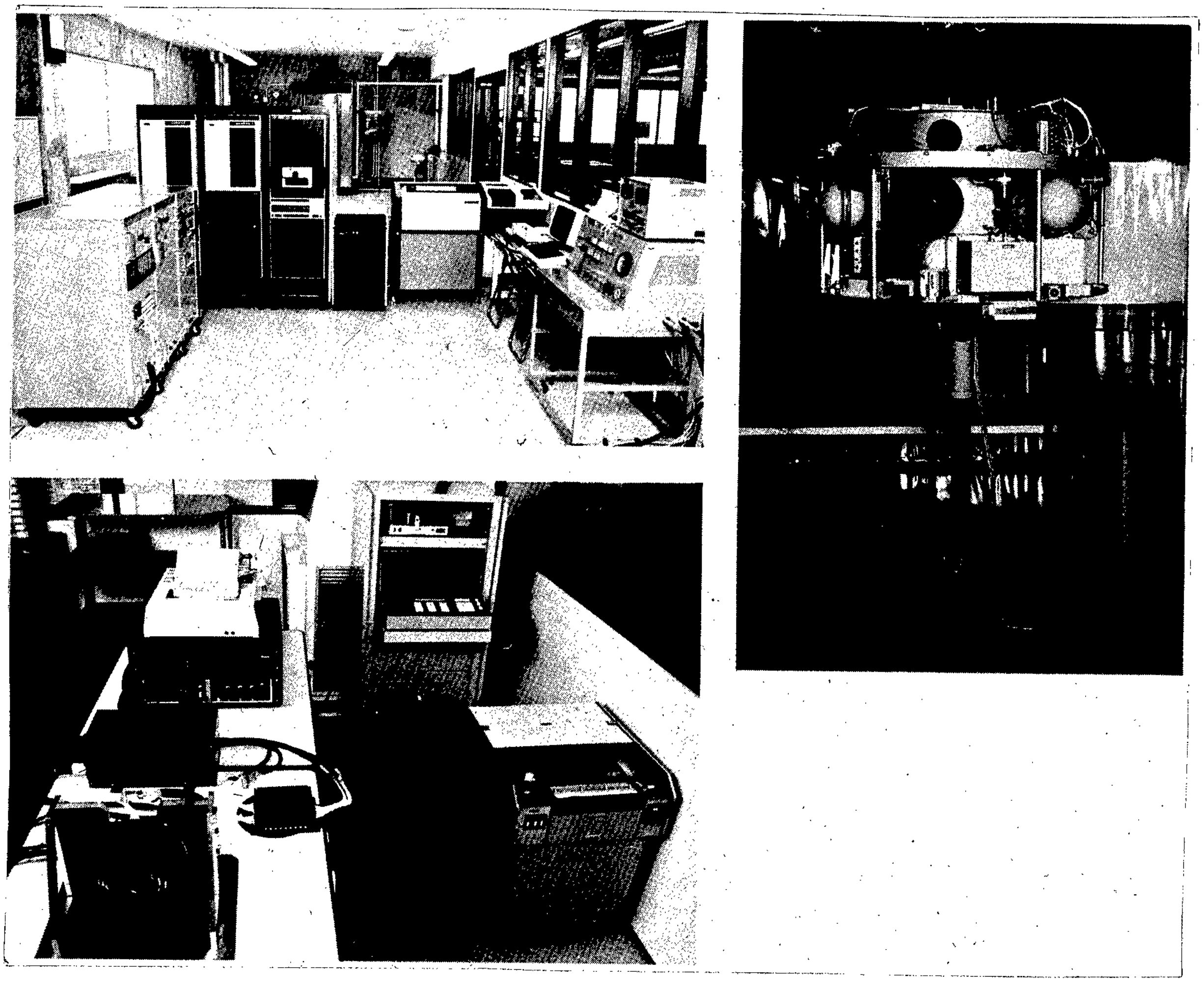


Electronic equipment to process [the data from] the terrestrial magnetism sensor

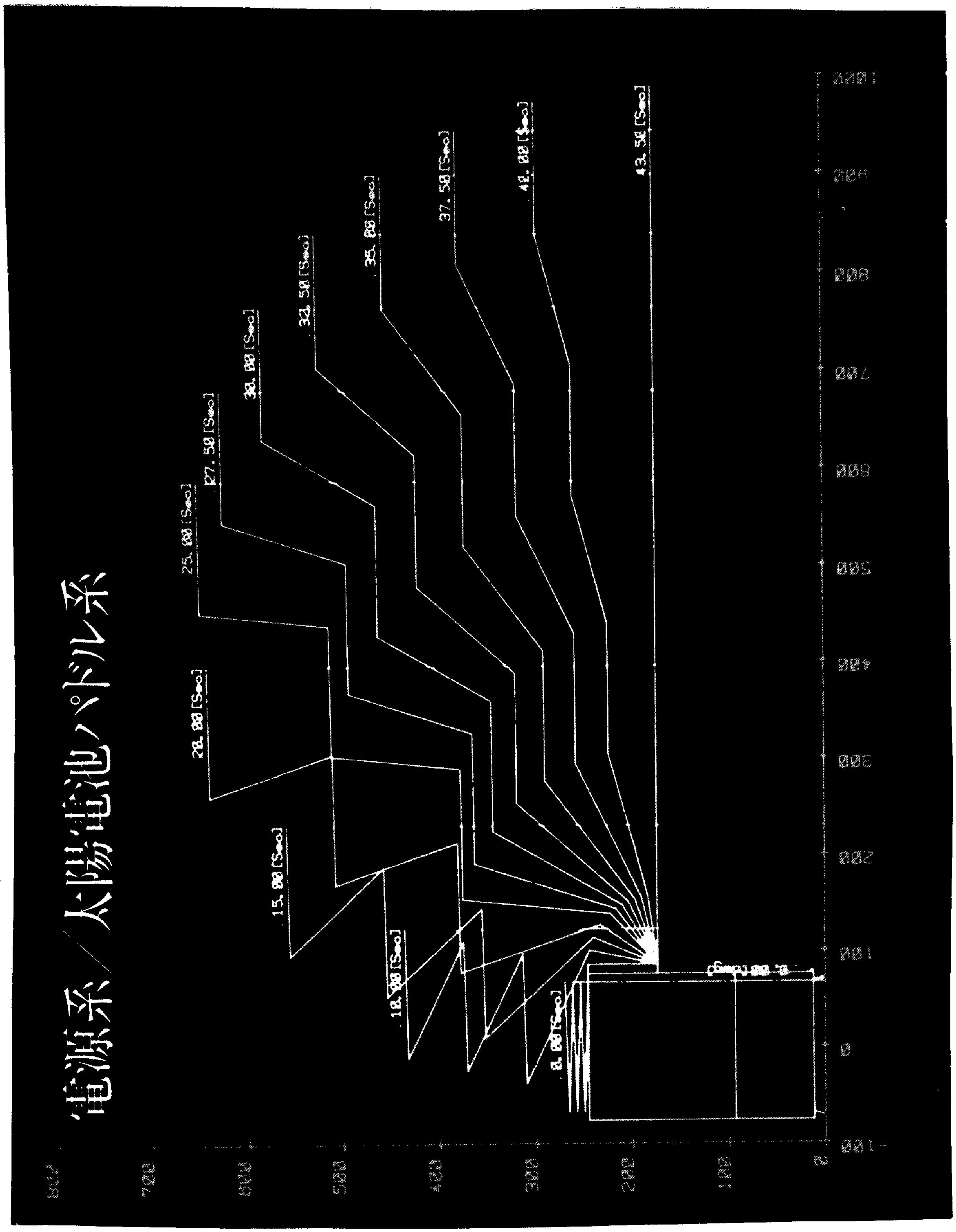
Terrestrial magnetism sensor



Sun sensor



Upper left : Dynamic simulator (computer section)
Lower left : Dynamic simulator (air bearing section)
Right : MS-T4 momentum wheel and its testing apparatus


電源系／太陽電池パドル系
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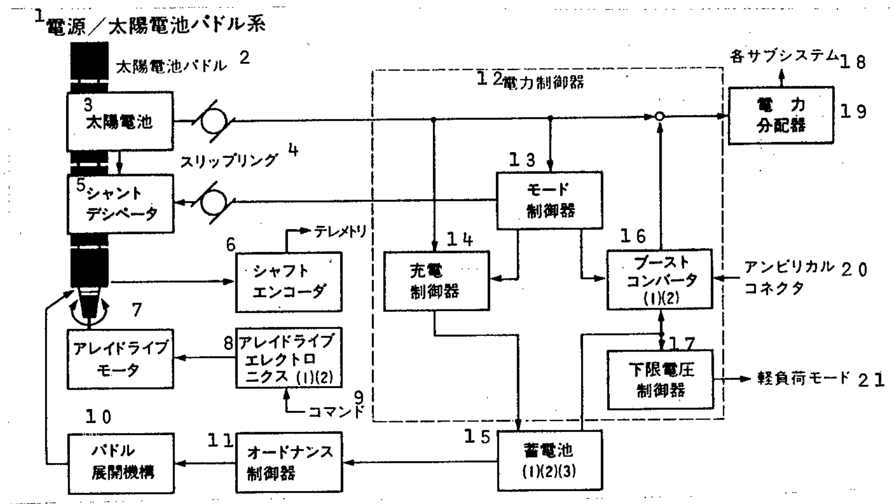
The power supply system provides uninterrupted electric power needed by the mission and bus equipment for 2 years during which the satellite performs its tasks. The electric power is generated by using the solar cells, and batteries are used when the satellite is in shadow.

To adapt to a solar synchronous orbit and to secure a field of vision for the mission equipment, the solar cell paddle has a single-sheet paddle configuration. The batteries consist of a 3-system parallel configuration. They are controlled by the charge regulator method, which has good electric power efficiency and bus voltage stability. For the shunt method, a sequence controlled through the partial shunt method, which enables a reduction of equivalent heat generation, is used. To decrease the number of power slip rings, the shunt dissipator was mounted on the paddle side, and the shunt resistance was mounted on the back side of the paddle to achieve better heat dissipation.

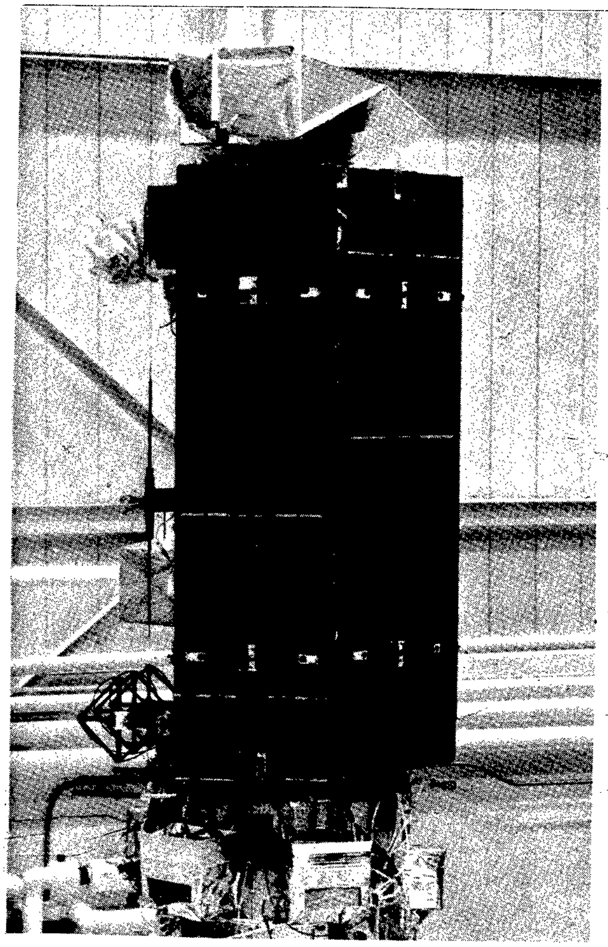
Power supply system data

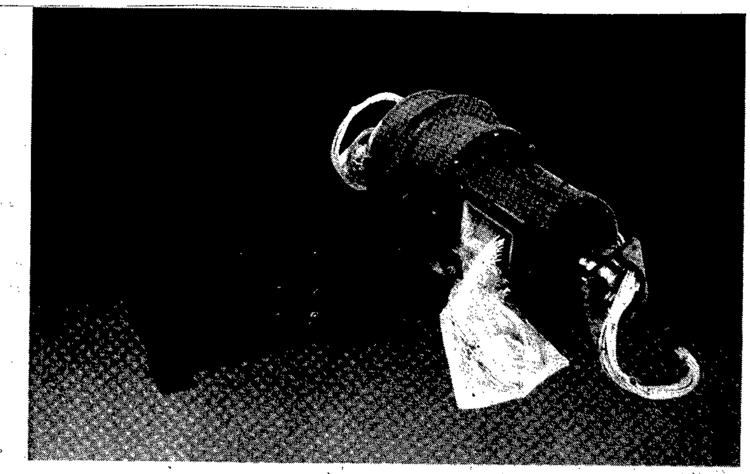
Solar cell	2 cm x 2 cm N/P silicon solar battery cell, a total of 94 x 234 = 21,996 sheets. 0.3 mm glass cover Generated power: BOL 670 watts, EOL 590 watts
Battery	Square, sealed Ni-Cd secondary batteries 15 AH x 17 in series x 3 systems Maximum discharge depth: at launch 34 percent, during operation 16 percent
Power controller	Charge mode/discharge mode/shunt mode: automatic switching Stabilized voltage 29V ± 2 percent
Shunt dissipator	Partial shunt method 24 circuits sequential control Maximum shunt processing capability: about 700 watts
Boost converter	More than 400 watts
Ordinance control circuit	Current with extended paddle 30 A (20 ms)

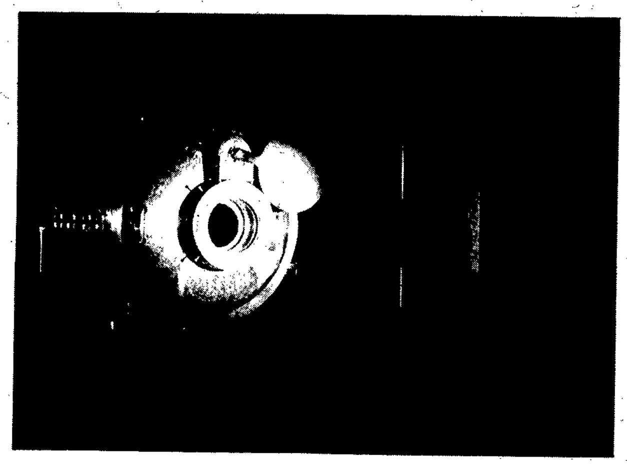


Key:

1. Power supply/solar cell paddle system
2. Solar cell paddle
3. Solar cell
4. Slip rings
5. Shunt dissipator
6. Shaft encoder
7. Array drive motor
8. Array drive electronics (1) (2)
9. Command
10. Paddle extension mechanism
11. Ordnance controller
12. Power controller
13. Mode controller
14. Charge controller
15. Batteries (1) (2) (3)
16. Boost converters (1) (2)
17. Lower limit voltage controller
18. Each subsystem
19. Power distributor
20. Umbilical connector
21. Light load mode
22. Telemetry





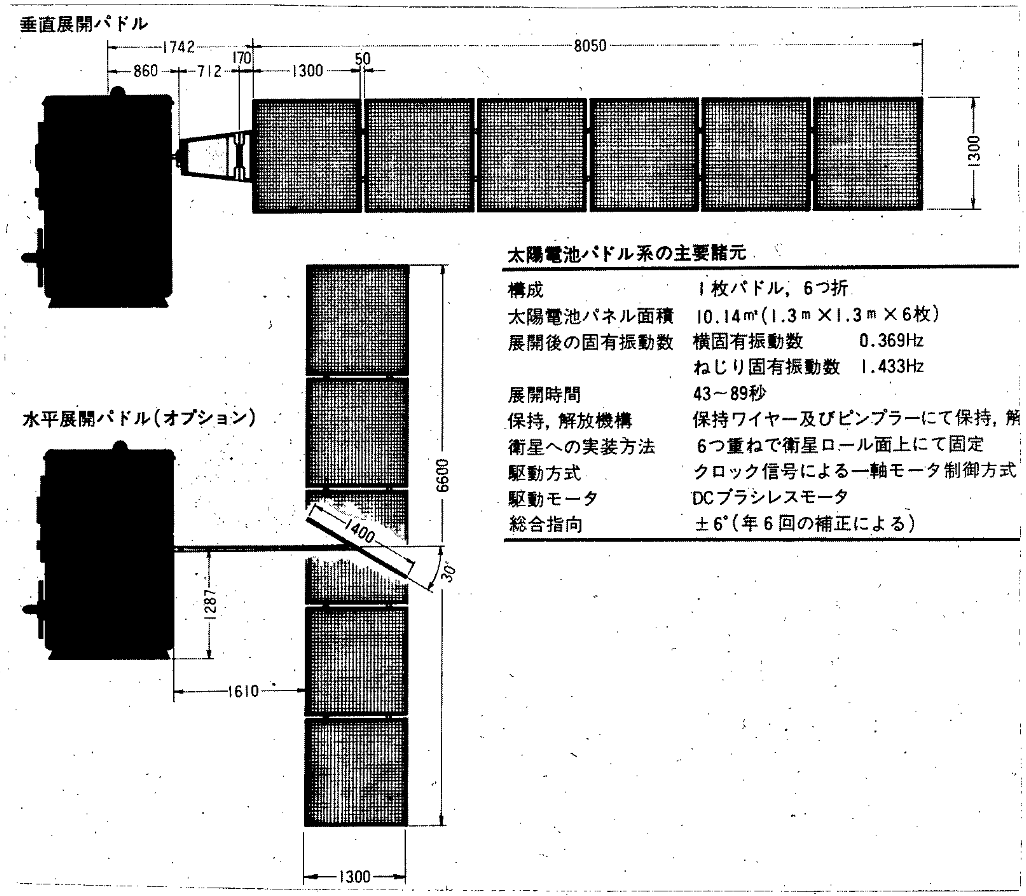


TIROS-N solar cell paddle

Upper: Array drive motor and electronics
Lower: Solar simulator

1

2

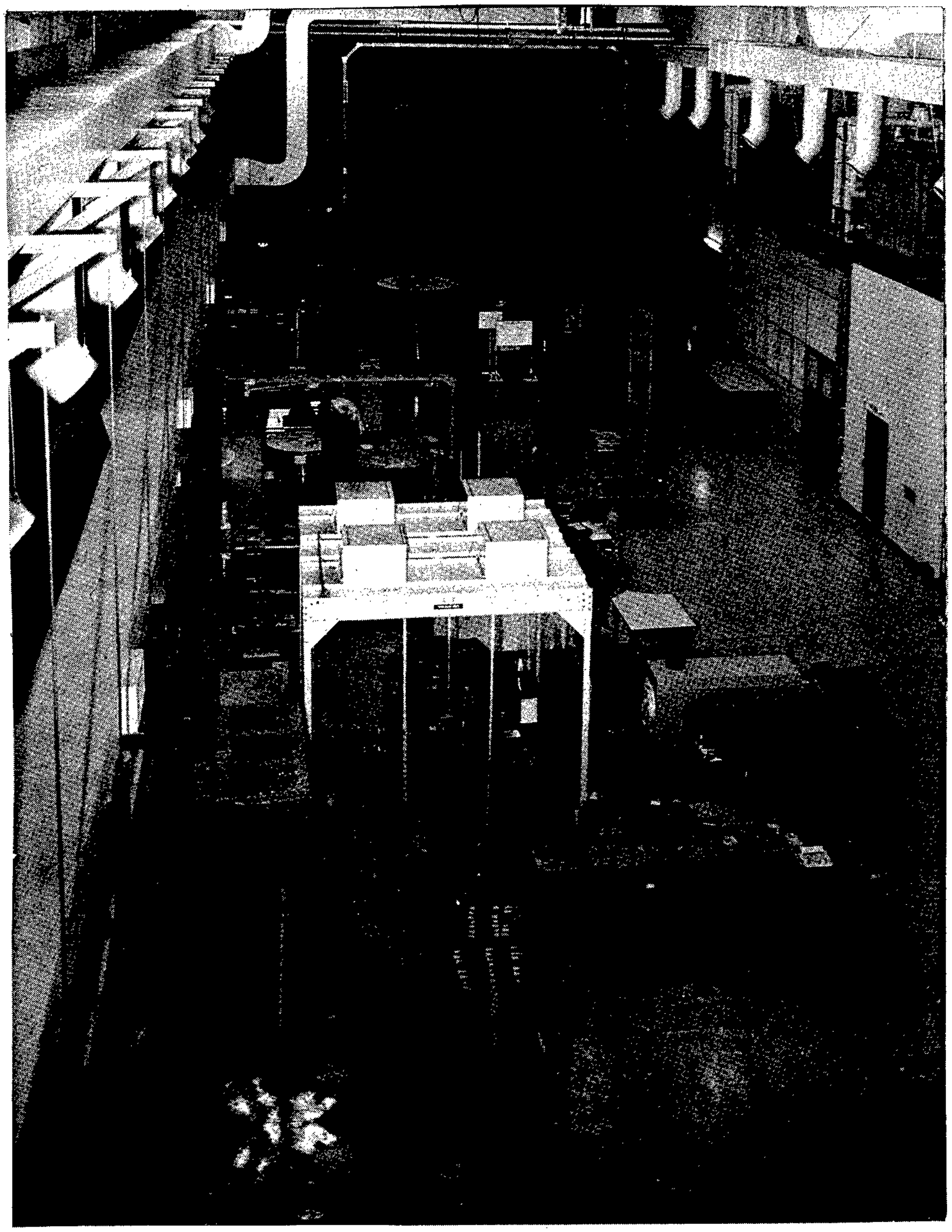


Key: 1. Vertically extended paddle　　2. Horizontally extended paddle (optional)

<u>Major data for the solar cell paddle system</u>

Configuration	Single sheet paddle, folded six times
Area of the solar cell panel	10.14 m^2 (1.3m x 1.3m x 6 sheets)
Characteristic frequency after the paddle is extended	Lateral proper frequency 0.369 Hz Twist proper frequency 1.433 Hz
Time required for extension	43-89 seconds
Retention and release mechanisms	Retention wire and pimpler are used for retention and release
Mounting method on the satellite	Folded six times and mounted on the satellite's roll side
Drive method	Single axis motor control by clock signals
Drive motor	DC brushless motor
Combined directionality	±6° (through 6 adjustments per year)

Airframe System



Space environment laboratory in which integration and testing of MOS-1 are carried out.

The airframe consists of a mission module, which houses mission equipment, and a bus module, which contains shared equipment. Each module uses an outer shell structure method that does not have a main frame.

- Design characteristics

- The frame was designed to make integration easier by dividing it into the mission and bus modules.
- Future expandability is guaranteed by adopting the module structure.
- The outer shell structure facilitates instrumentation and checkout and efficiently uses the space that is available for mounting [the instruments].

Satellite structure, major dimensions, and weight

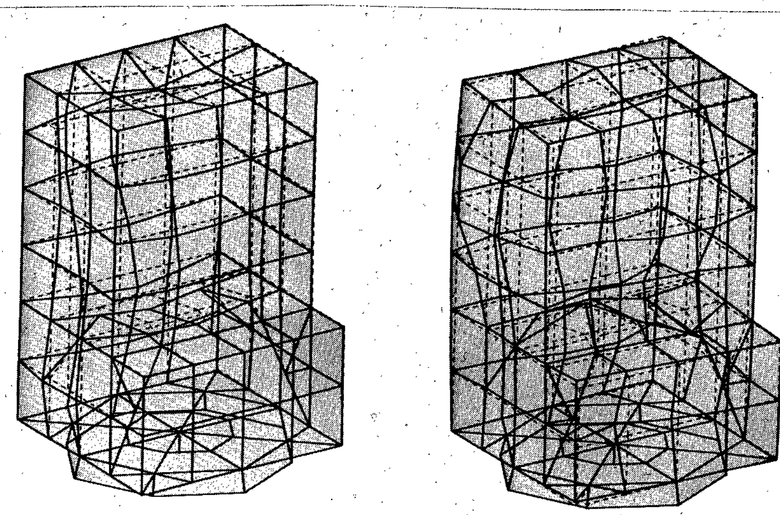
Dimensions	1.4m (length) x 1.5m (width) x 2.5m (height)
Mission module	1.1m (length) x 1.5m (width) x 1.5m (height)
Bus module	1.4m (length) x 1.5m (width) x 1.0m (height)
Weight	
Mission module	65.7 kg
Bus module	54.3 kg
	120.0 kg

Major structural materials

Mission module panel
  30/40mm honeycomb sandwich structure
  Surface panel made of high strength aluminum alloy
  Core made of corrosion resistant aluminum alloy
Bus module panel
  30/40mm honeycomb sandwich structure
  Surface panel made of high strength aluminum alloy
  Core made of corrosion resistant aluminum alloy
Adaptor ring
  Machine processed
  High strength, forged aluminum alloy

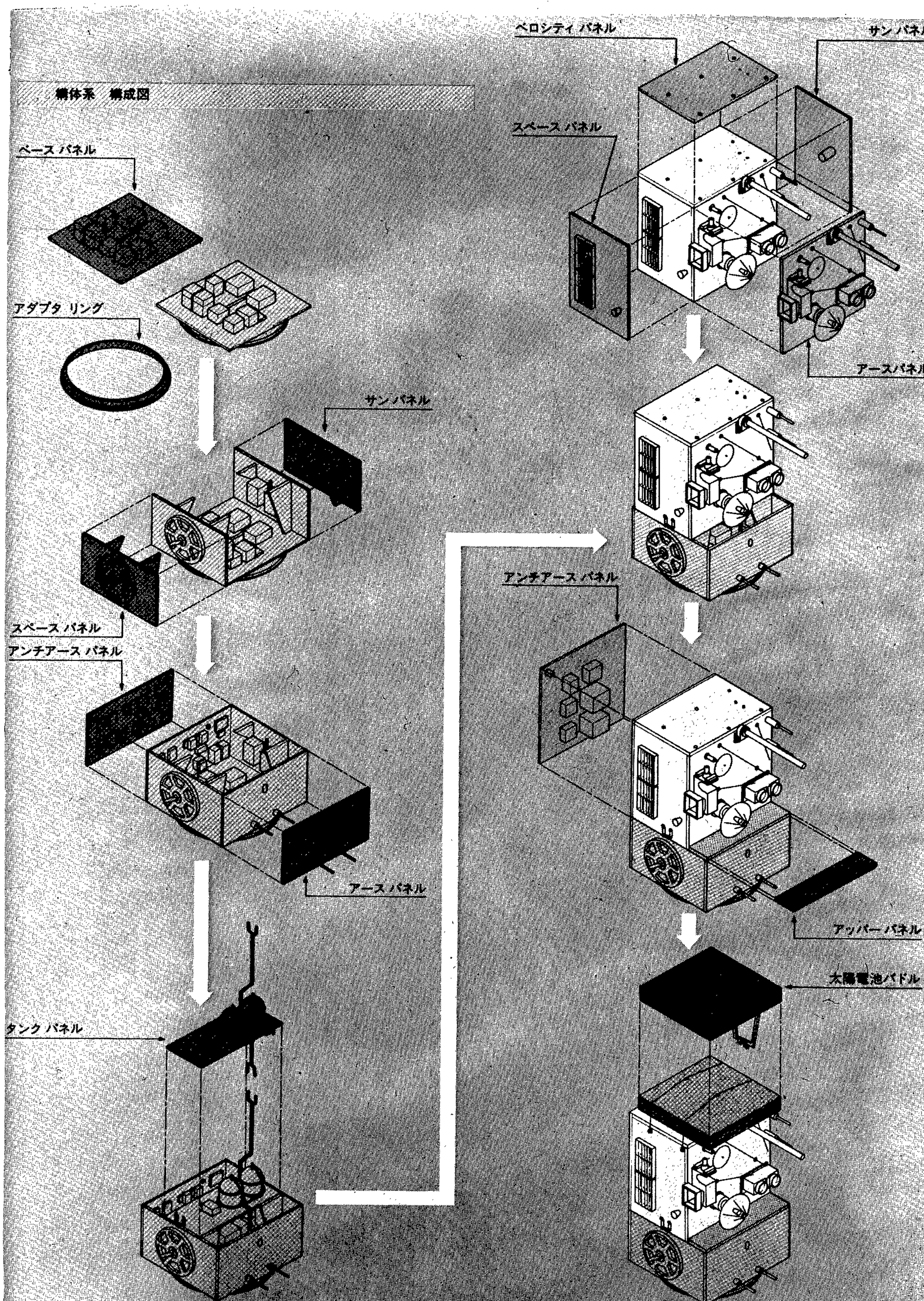
Results of structural analysis

Proper frequency (at launch)	
Thrust axis direction, primary	61 Hz
Lateral, primary	16 Hz
Proper frequency (in orbit)	0.37 Hz
Safety tolerance rate of major structural materials	
Mission module earth panel	2.6
Mission module panel	3.4
Bus module base panel	1.7
Bus module panel	1.4
Adaptor ring	1.6



Key: [to page 29 diagram]

1. Composition of airframe system
2. Base panel
3. Adaptor ring
4. Sun panel
5. Space panel
6. Anti-earth panel
7. Earth panel
8. Tank panel
9. Velocity panel
10. Upper panel
11. Solar cell paddle


1 構体系　構成図
2 ベース パネル
3 アダプタ リング
4 サン パネル
5 スペース パネル
6 アンチアース パネル
7 アース パネル
8 タンク パネル
9 ベロシティ パネル
4 サン パネル
5 スペース パネル
7 アースパネル
6 アンチアース パネル
10 アッパー パネル
11 太陽電池パドル

Thermal Control System

The thermal control system is based on a passive method, but it uses some active modes (thermal louver and heater) as well. The satellite surface consists of two panels. One panel actively controls thermal conditions by making its surface dissipate heat efficiently, while the other panel restricts heat exchange with the outside by insulating its surface with thermal blankets. The main part of the thermal control panel is the pitch side, and the auxiliary parts are the yaw side and roll side.

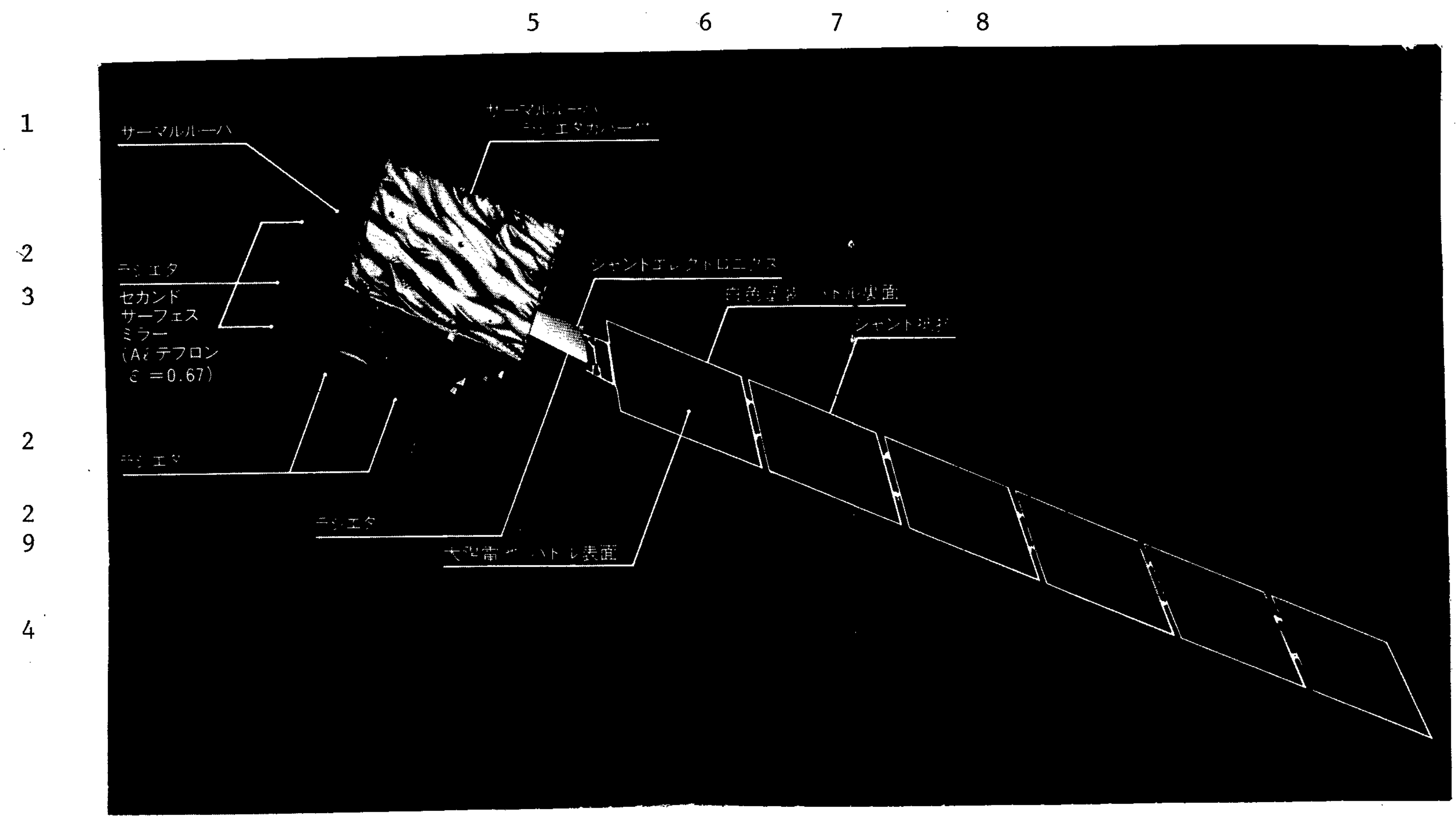
The equipment in the bus system is mostly installed on the heat dissipation side of the thermal control panel, and the apparatus in the mission system that generates much heat is equipped with thermal louvers. The interior of the satellite is painted black to make the inside temperature of the satellite uniform. The gas yet system is equipped with a heater in order to prevent chilling. The temperature of the batteries is also controlled by a heater.

- Design characteristics

- Design is based on the passive type, which our company has much experience with, while the active type is also used to create an environment with safe temperatures.
- Operation is made much simpler by using thermal control elements which are driven and controlled on board.

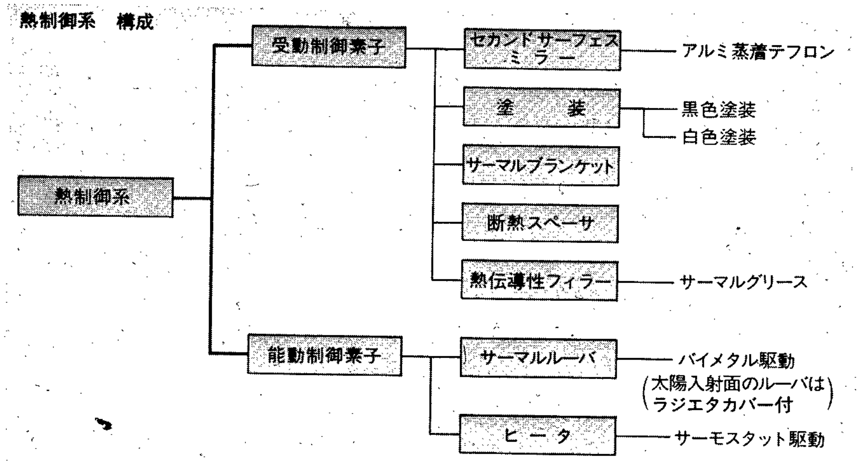
<u>Thermal control system data</u>

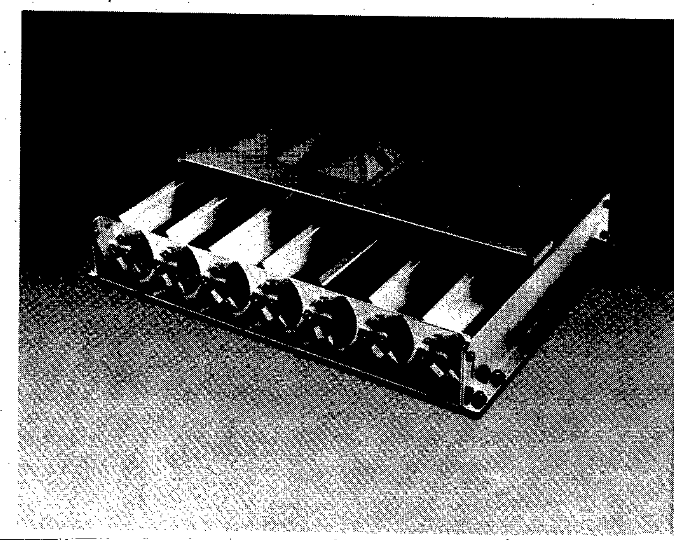
Electric power for heaters		
Battery	22 watts	
Gas jet system (excluding the catalytic heater)	15 watts	
Thermal louvers	0.25m x 0.3m	10 units
	0.2 m x 0.22m	1 unit
	0.4 m x 0.22m	1 unit
Passive heat dissipation surface		
Total area	About $13.7m^2$, $\varepsilon = 0.67$	
Design temperatures		
Margins for operating temperatures		
Critical apparatus	0°C (Required: 0°C or higher)	
Other apparatus	15°C (Required: 15°C or higher)	



Sketch of the Thermal Control System

Key:
1. Thermal louver
2. Radiator
3. Second surface mirror (Aℓ teflon, ε = 0.67)
4. Direction of the earth
5. Thermal louver (with a radiator cover)
6. Shunt electronics
7. Painted white (back side of the paddle)
8. Shunt resistance
9. Solar cells (paddle surface)

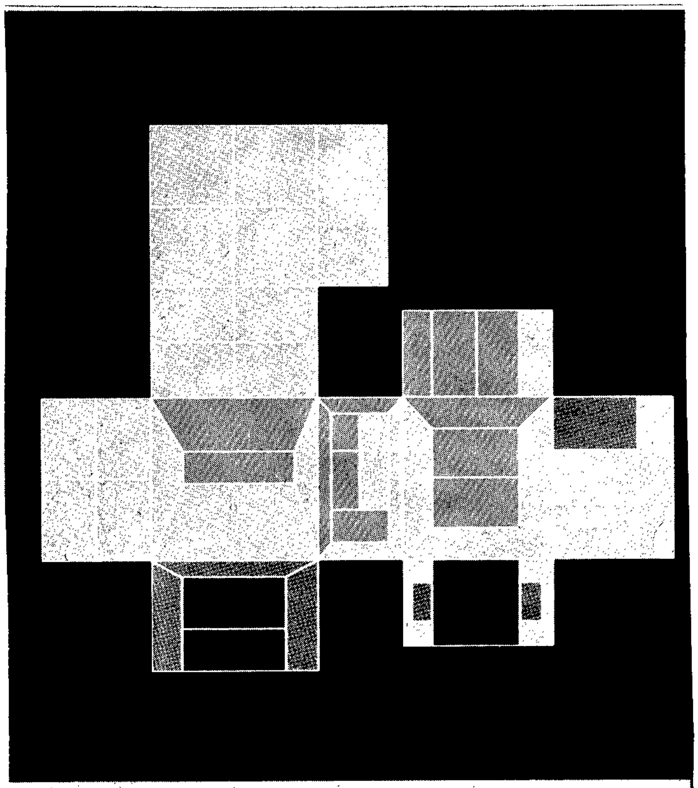




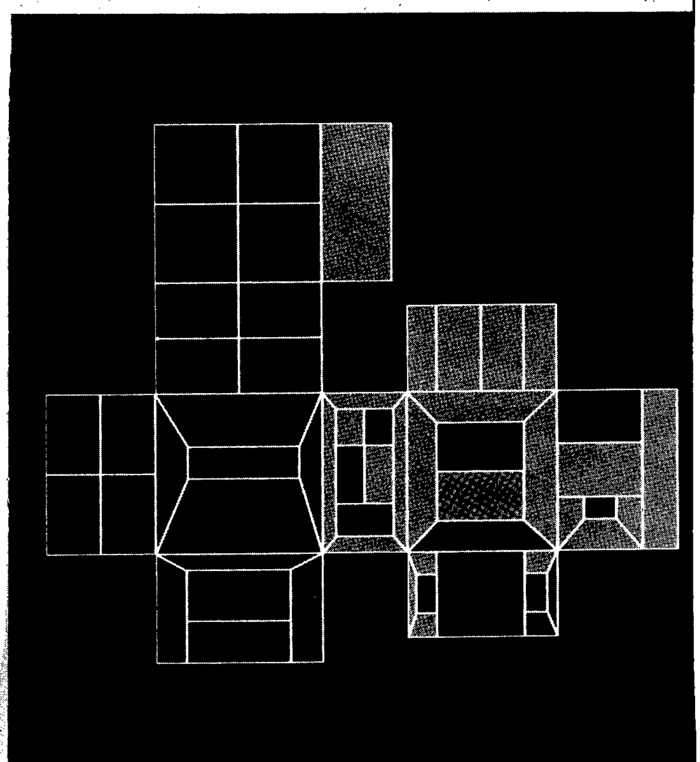
1-2　3-4　5-11　12-17

Test sample of a thermal louver

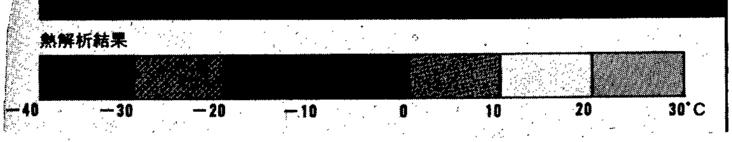
Key:
1. Composition of the thermal control system
2. Thermal control system
3. Passive control elements
4. Active control elements
5. Second surface mirror
6. Painting
7. Thermal blanket
8. Insulation spacer
9. Heat conductive filler
10. Thermal louvers
11. Heaters
12. Aluminum evaporated teflon
13. Painted black
14. Painted white
15. Thermal grease
16. Driven by bimetal (the louver that faces the sun has a radiator cover)
17. Driven by thermostats



Anticipated temperatures (upper limit)



Anticipated temperatures (lower limit)



Color chart for the thermal analysis results

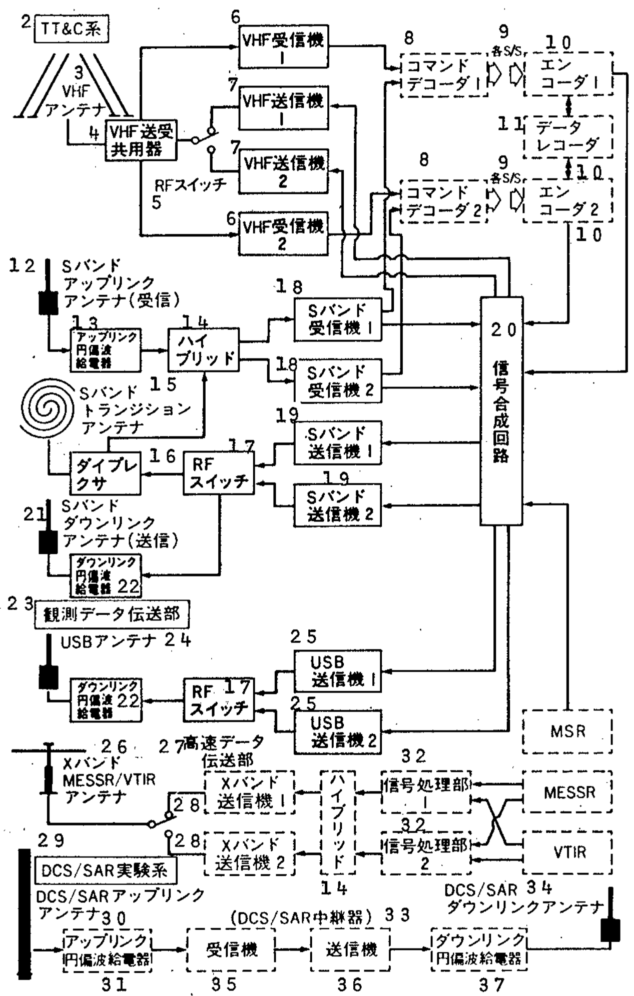
Communication System/Antenna System

The communication subsystem consists of telemetry, a command system, an observation data transmission system, and a data collection system/search and rescue experimental system.

- Design characteristics

- TT&C system used methods that were also used on the ETS-III satellite as much as possible.
- The S-band range finding can be carried out by two stations simultaneously.
- The USB and X-band are used for the transmission of observed data to allow reception by existing foreign stations.
- A remodulation type has been adopted for DCS/SAR relay in consideration of future on-board data processing.
- Mutual interference between many frequencies are minimized.

1 MOS-1 通信系機能系統図

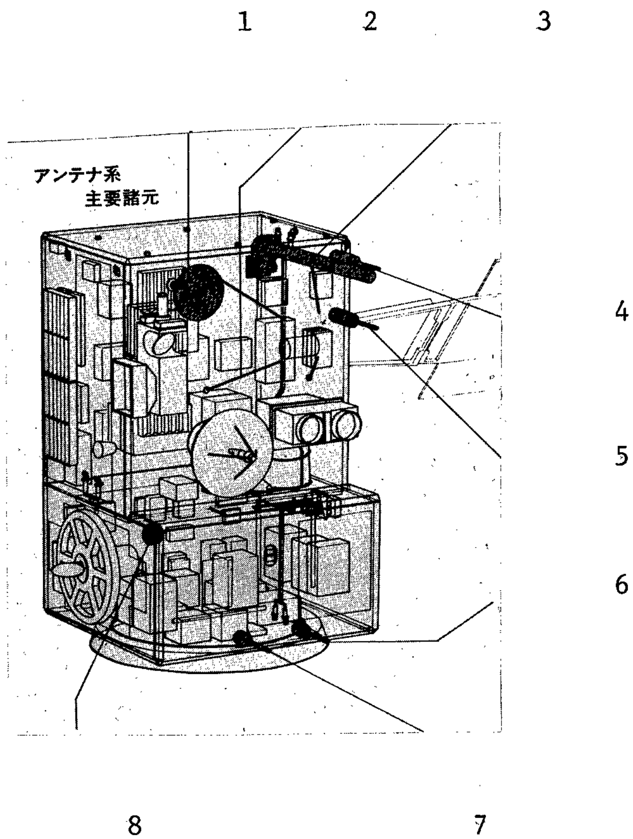


[key on next page]

Key: [to page 34 diagram]

1. MOS-1 communication system function chart
2. TT&C system
3. VHF antenna
4. Shared equipment for VHF transmitter and receiver
5. RF switch
6. VHF receiver
7. VHF transmitter
8. Command decoder
9. Each S/S
10. Encoder
11. Data recorder
12. S-band up-link antenna (for reception)
13. Up-link, circularly polarized wave feeder
14. Hybrid
15. S-band transition antenna
16. Diplexer
17. RF switch
18. S-band receiver
19. S-band transmitter
20. Signal synthesizing circuit
21. S-band down-link antenna (for transmission)
22. Down-link, circularly polarized wave feeder
23. Observation data transmission section
24. USB antenna
25. USB transmitter
26. X-band MESSR/VTIR antenna
27. High speed data transmission section
28. X-band transmitter
29. DCS/SAR experimental system
30. DCS/SAR up-link antenna
31. Up-link, circularly polarized wave feeder
32. Signal processing section
33. DCS/SAR relay
34. DCS/SAR down-link antenna
35. Receiver
36. Transmitter
37. Down-link, circularly polarized wave feeder

Major Data for the Antenna System



Key:

1. X-band antenna

Type	Turnstyle
Frequency	8.4 GHz band
Polarization	Right circularly polarized wave

2. VHF antenna

Type	Monopole
Frequency	136 MHz band (down link) 148 MHz band (up link)
Polarization	Right and left circularly polar-ized waves

3. UHF antenna for DCS/SAR up-link

Type	Quadrifilar helical
Frequency	406 MHz band
Polarization	Right circularly polarized wave

4. USB antenna

Type	Quadrifilar helical
Frequency	2.2 GHz
Polarization	Right circularly polarized wave

5. L-band antenna for DCS/SAR down-link

Type	Quadrifilar helical
Frequency	1,543 MHz
Polarization	Right circularly polarized wave

6. S-band down-link antenna

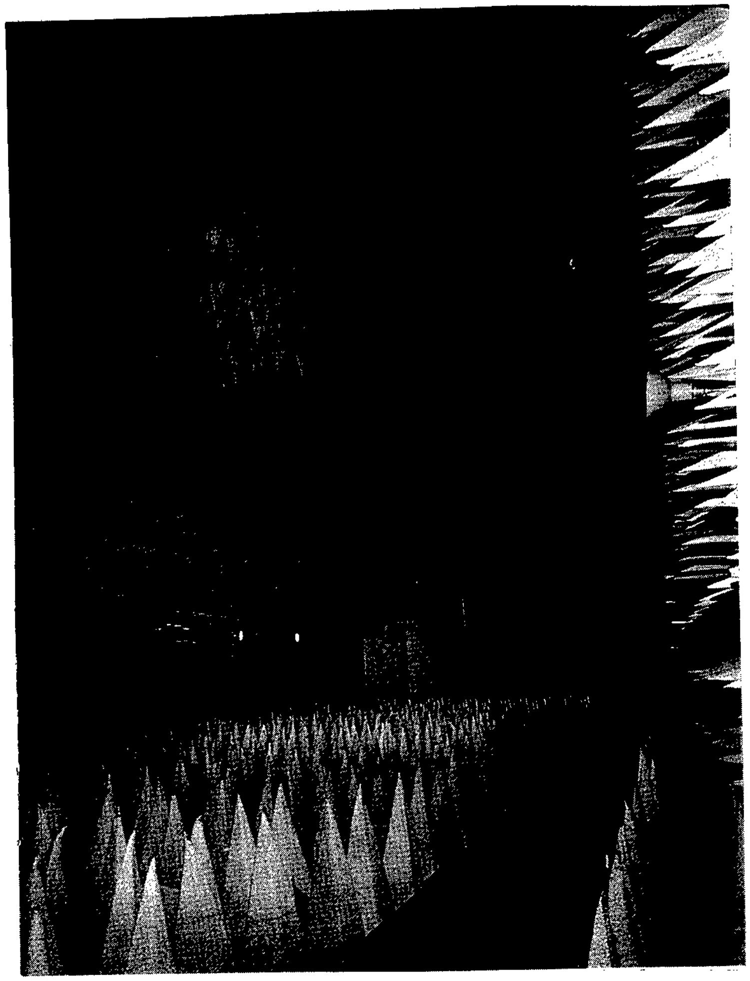
Type	Quadrifilar helical
Frequency	1.7 GHz band
Polarization	Right circularly polarized wave

7. S-band up-link antenna

Type	Quadrifilar helical
Frequency	2.1 GHz band
Polarization	Right circularly polarized wave

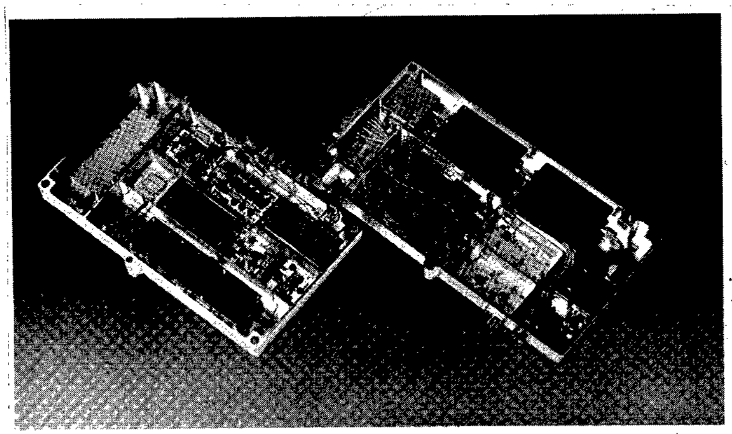
8. S-band transition antenna

Type	Spiral
Frequency	1.7 GHz (down-link);2.1 GHz (up-link)
Polarization	Right circularly polarized wave

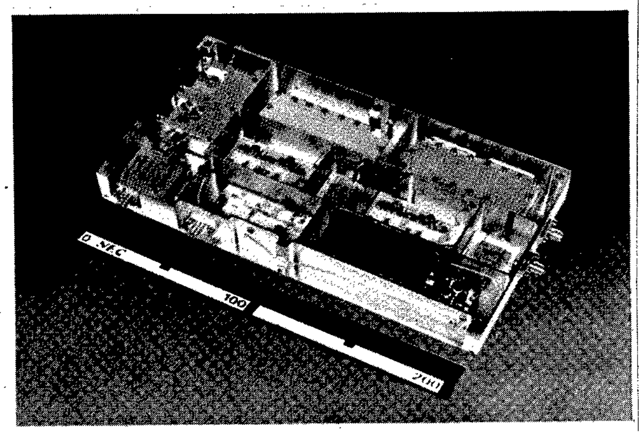


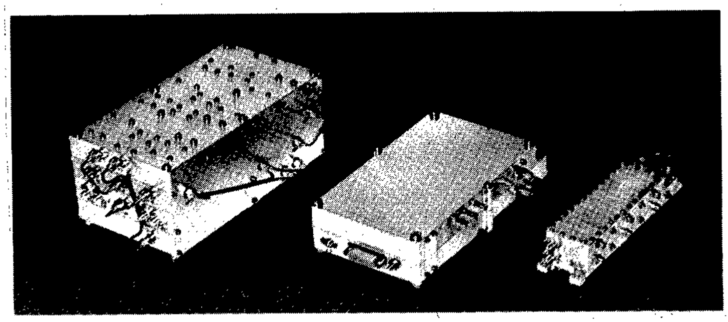
Radio wave dark room

USB transmitter

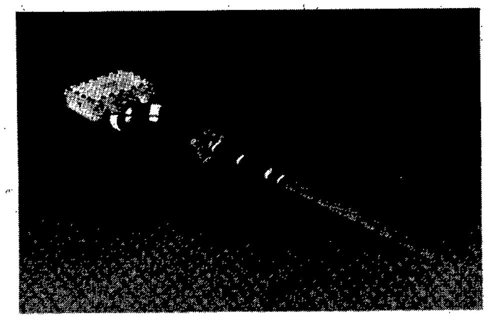


S-band receiver





S-band transmitter, receiver and diplexer



Quadrifilar helical antenna

Data for Communication System

TT&C system

Telemetry

	VHF	S-band	USB
Modulation method	PCM-PM	PCM-FM-PM PCM-PM*	PCM-FM-PM
Carrier wave frequency	136.11 MHz	1705.0 MHz	2280.0 MHz
Modulation index	1.0 radian	0.35 radian 0.7 radian	0.5 radian
Transmission output	1.0 W	0.3 W	0.1 W
Bit rate	1,024 bps (real time), 26.624k bps (replay)		
Code type	Split phase level		
Subcarrier frequency	87.5 KHz		

*(replay)

Command

	VHF	S-band
Modulation method	PCM-FSK/AM-PM	PCM-FSK/AM-PM
Carrier wave frequency	148.27 MHz	2115.6 MHz
Modulation index	0.9 radian	0.4 radian
Noise index	8.0 dB	3.0 dB
Bit rate	128 bps	
FSK frequency	"1" 8600 Hz, "0" 7400 Hz	
AM Modulation index	50 percent	

Ranging

	Up-link	Down-link
R&RR method	PN code ranging tone (distance) Two-way doppler (rate of change in distance) Simultaneous measurement from two different stations is possible	
Modulation method	PRN-PSK-PM	PRN-PSK-PM-PM
Carrier wave frequency	2115.6 MHz, 2117.8MHz	1705.0 MHz
Modulation index	1.0 radian	0.35 radian/CH
Subcarrier frequency	--	1.4 MHz, 3.6 MHz
PN code bit rate	125 kbps	
PSK frequency	500 KHz	

Observation data transmission system

MSR/MESSR/VTIR

	USB(MSR)	X-band (MESSR/VTIR)
Modulation method	PCM-PM	PCM-MSK
Carrier wave frequency	2286.0 MHz	8400 MHz
Modulation index	0.7 radian	--
Transmission output	0.1 W	4.0 W
Bit rate	2000 bps	8.78M bps
Code type	BIϕ-L serial	NRZ-M

[continued]

DCS/SAR experiment system		
DCS/SAR relay		
	Up-link	Down-link
Relay method	Remodulation type	
Modulation method	PCM-PM	PCM-PM-PM
Carrier wave frequency	406.0 MHz	1543.0 MHz
Modulation index	1.2 radian	1.0 radian
Subcarrier frequency	--	200 KHz
Bit rate	128 bps	
Code type	Biphase level	

Telemetry/Command System

The telemetry/command system consists of a telemetry encoder, a remote telemetry unit, a command decoder, and a data recorder. We used the same methods as those used on EST-III as much as possible. The data recorder is on board in order to receive telemetry data [collected] in invisible regions. For commands, we use discrete magnitude and stored commands. It is possible to operate the satellite through a single station in Japan.

Major functions of the telemetry and command system are listed below.

- Functions of the telemetry system

- Telemetry signals are encoded and transmitted through the S-band, USB, or VHF band.
- To monitor the operation of the satellite in the regions which cannot be observed [from Japan] directly, telemetry signals are stored in a data recorder, and then they are replayed at high speed when the satellite is visible from the ground station.

- Functions of the command system

- Switching and control of satellite operations are carried out by receiving command signals through the S-band and VHF band.
- The command operations can provide real time control and delayed control through timers.

Major data for telemetry/encoder system

Data format	
1 minor frame	128 words (per second)
1 major frame	8 minor frames
1 word length	8 bits
Frame cycle	24 bits
Bit rate	1,024 bps
Input	
Analog input	279 CH 0-5 V {254 CH (1/8), 25 CH (1/1)}
Serial digital input	30 CH {2 CH (1/8), 28 CH (1/1)} "1" 5 V, "0" OV
Bilevel digital input	165 CH "1" 5 V "0" OV

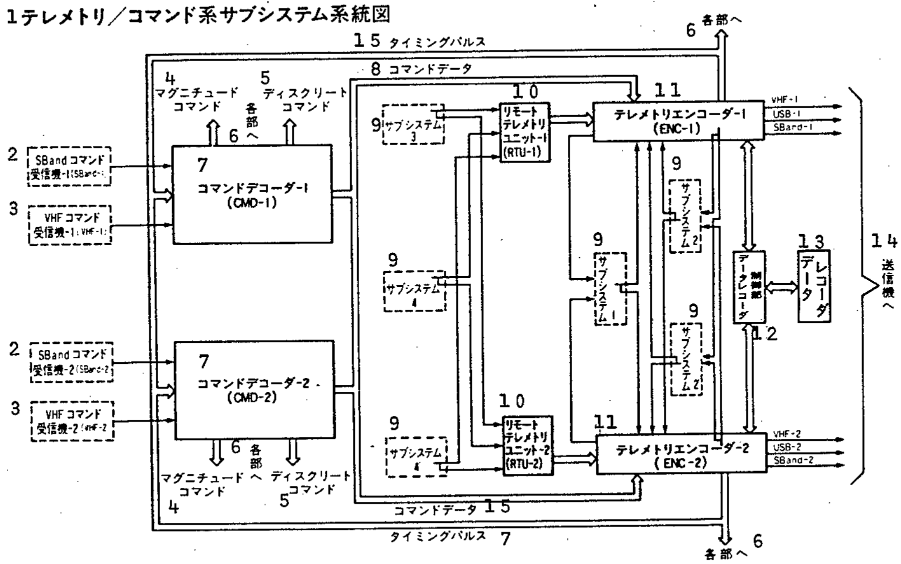
Major data for the data recorder

Data input channel	1 channel (2 tracks)
Recording time	105 minutes Min [minimum?] (105 minutes/2/track)
Replay time	4 minutes Min (2 minutes/track)
Replay/record ratio	26/1
Recording data	1,024 bps Biϕ-L
Replaying data	26,624 bps Biϕ-L

Major data for the command system

Bit rate	1 channel (2 track)	
Command format	Type I	Discrete commands
	Type II	Discrete commands (without verification)
	Type III	Magnitude commands
	Type IV	Magnitude commands (without verification)
	Type V	Stored commands
Word configuration		
Command word length	8 bits	
Magnitude word length	14 bits	
Synchronous word length	19 bits	
Satellite address	7 bits	
Real time commands		
Discrete commands	254 (MAX)	<All "0", excluding "1" code>
Magnitude commands	32 (MAX)	
Stored commands		
Discrete commands	16 (MAX)	
Maximum delay time in command execution	18.2 hours	

1テレメトリ／コマンド系サブシステム系統図



Key:

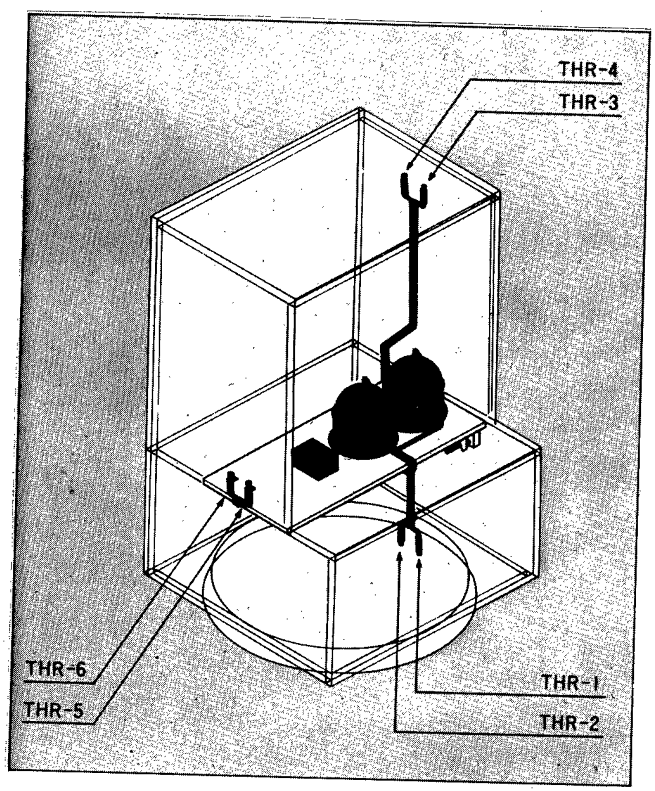
1. Telemetry/command system subsystems chart
2. S-band command receiver
3. VHF command receiver
4. Magnitude command
5. Discrete command
6. To various sections
7. Command decoder
8. Command data
9. Subsystem
10. Remote telemetry unit
11. Telemetry encoder
12. Data recorder control section
13. Data recorder
14. To transmitter
15. Timing pulse

Gas Jet System

The gas jet system consists of two propellant tanks, six thrusters, four filling and draining valves, two filters, four shutoff valves, and piping. This system performs the following functions.

- Orbital correction to achieve solar synchronous orbit after the satellite has been inserted into its initial orbit.
- Maintenance of the solar synchronous orbit during the mission period.

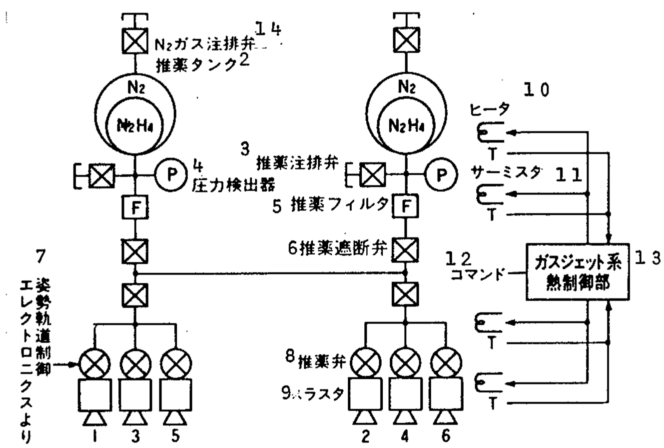
In order to facilitate the installation and integration of the gas jet system to the satellite, major equipment in the system has been concentrated on the bus equipment side and has been formed into modular subsystems. Also, to minimize shifting of the center of gravity as the propellant is spent, the fuel tank is installed over the center of gravity. The thrusters are arranged to remove plume impingement and sensor contamination. Furthermore, to avoid external disturbance to the satellite's attitude, the thrust axis of each thruster passes through the center of gravity of the satellite.



Major data for the gas jet system

Orbit control	
Control inside the orbital plane	± roll direction 2N THR - (1,2);(3,4)
Control outside the orbital plane	- pitch direction 2N THR - (5,6)
Propellant tanks	
Type	Titanium alloy, spherical, all welded, contains bladder, polar mount type
Capacity	9.8 kg
Number	Two tanks
Thruster	
Type	IN thruster, unit coupled with propellant
Catalysis	Shell 405
Number	Six units

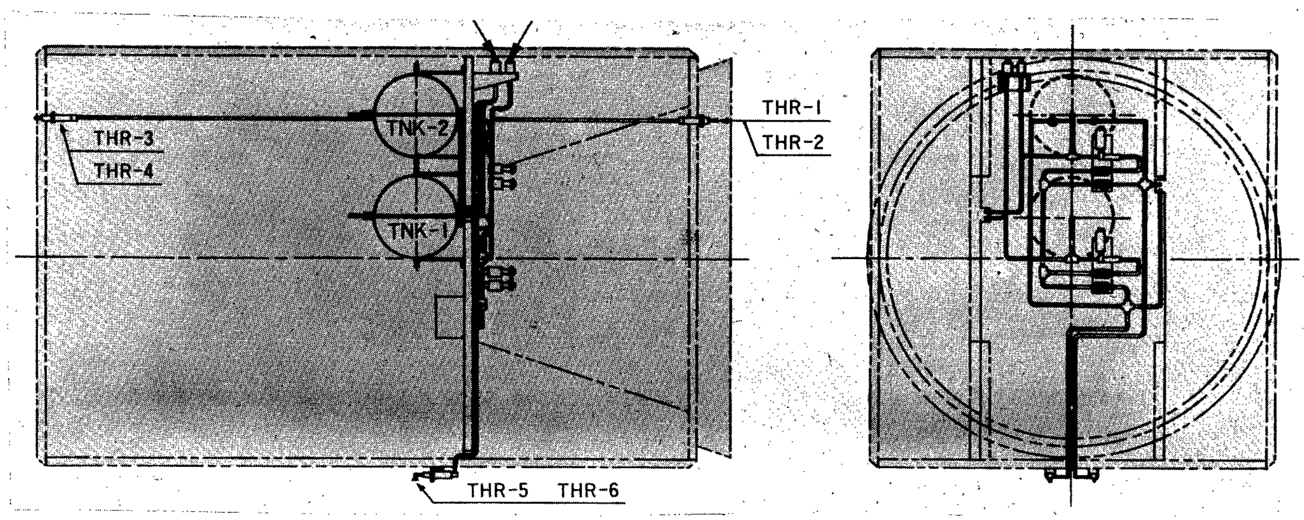
1
ガスジェット系統図



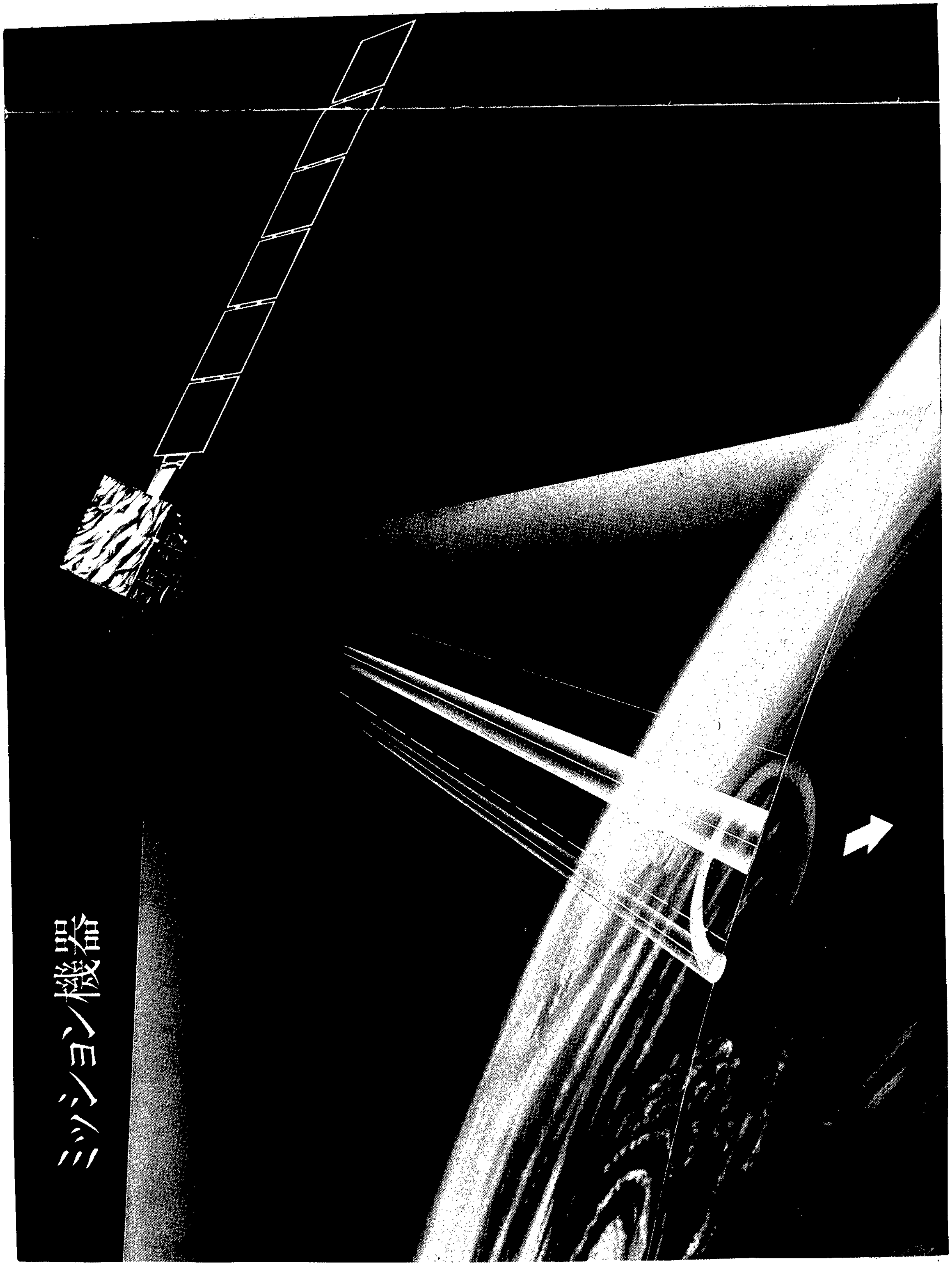
Key:
1. Gas jet system chart
2. Propellant tank
3. Propellant filling and draining valve
4. Pressure detector
5. Propellant filter valve
6. Propellant shutoff valve
7. Attitude orbit control signals from electronic [circuits]
8. Propellant valves
9. Thrusters
10. Heater
11. Thermister
12. Command
13. Gas jet system heat control section
14. N_2 gas filling and draining valve

N$_2$ gas filling and draining valve

N$_2$H$_4$ propellant filling and draining valve



Mission Equipment



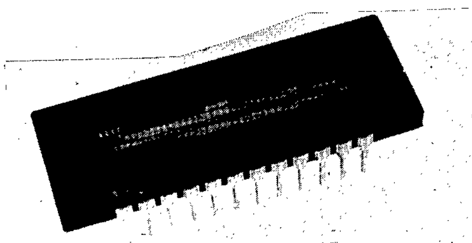
- Visible near-infrared radiometer

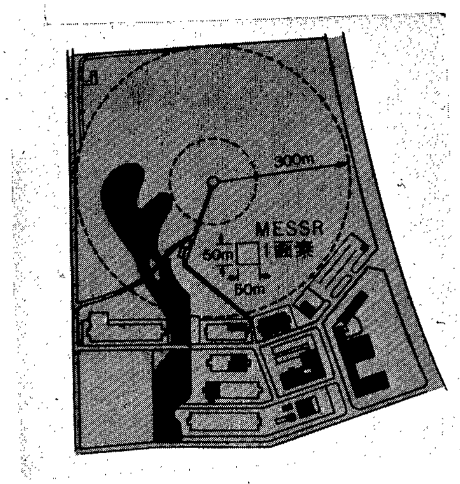
The visible near-infrared radiometer (MESSR) maps light reflected from the ground and sea surfaces in four colors between visible light and near-infrared, and it gathers maritime information such as sea surface pollution and water color. A CCD sensor with 2,048 elements is used to obtain two-dimensional images by using electrical scanning and orbital motion.

The scanning width on the ground is about 100 km, and one image element corresponds to about 50 m x 50 m on the ground. The processed digital signals are transmitted by the high speed data transmission section at the rate of 8.78 Mbit/sec. The data from the visible thermal infrared radiometer are multiplexed in the MESSR signal processing section. MESSR signals are transmitted in the X-band, similar to the frequency planned for Landsat-D.

- Visible thermal infrared radiometer

The purpose of the visible thermal infrared radiometer (VTIR) is to collect data on cloud and sea surface temperatures. It maps the images of land and sea with visible and thermal infrared wavelengths. For this purpose, VTIR uses one visible band and three infrared bands and rotates a scanning mirror by a mechanical rotating scanning method. The collected data are transmitted after they are multiplexed onto the MESSR signals.





* Image elements

Data for MESSR

Scanning method	Electronic scanning
Detector	CCD array
Instantaneous field of vision	54.5 μrad
Scanning width	102 km
Scanning time	7.61m sec
Observation wavelength	Band 1 0.51-0.59 Band 3 0.72-0.8 2 0.64-0.72 Band 4 0.8-1.1
Number of elements	Each band 0248
Operating conditions	Alternating operations of two opitcal systems

Data for VTIR

Scanning method	Mechanical rotation scanning method
Instantaneous field of vision	1 m rad (Visible [wavelength]) 3 m rad (Thermal [infrared wavelength])
Scanning width	1,500 km
Scanning time	0.137 sec (one rotation)
Observation wavelength (μm)	0.5-0.7 6.0-7.0 10.5-11.5 11.5-12.5

- Microwave radiometer

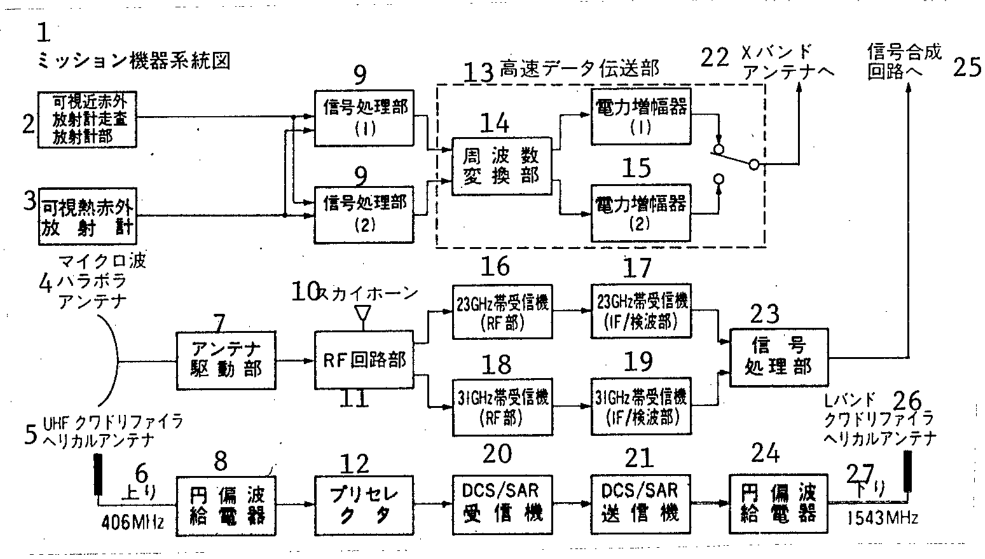
The microwave radiometer (MSR) maps images of land and sea with microwave band to acquire data on the amount of water vapor on the ocean surface and in the atmosphere, the amount of water, and sea ice. MSR uses two microwave bands for this purpose, and rotates an antenna by the mechanical rotation scanning method.

Data for the microwave radiometer

Scanning method	Mechanical rotation scanning method
Beam width	2.4° Lower than [the indicated angles] (23 GHz) 1.8° Lower than [the indicated angles] (31 GHz)
Scanning width	320 km
Scanning time	3.2 sec (one rotation)
Observation frequency	23.8 GHz 31.4 GHz
Temperature resolution	1°K (23 GHz) 3°K (31 GHz) (Estimated values)

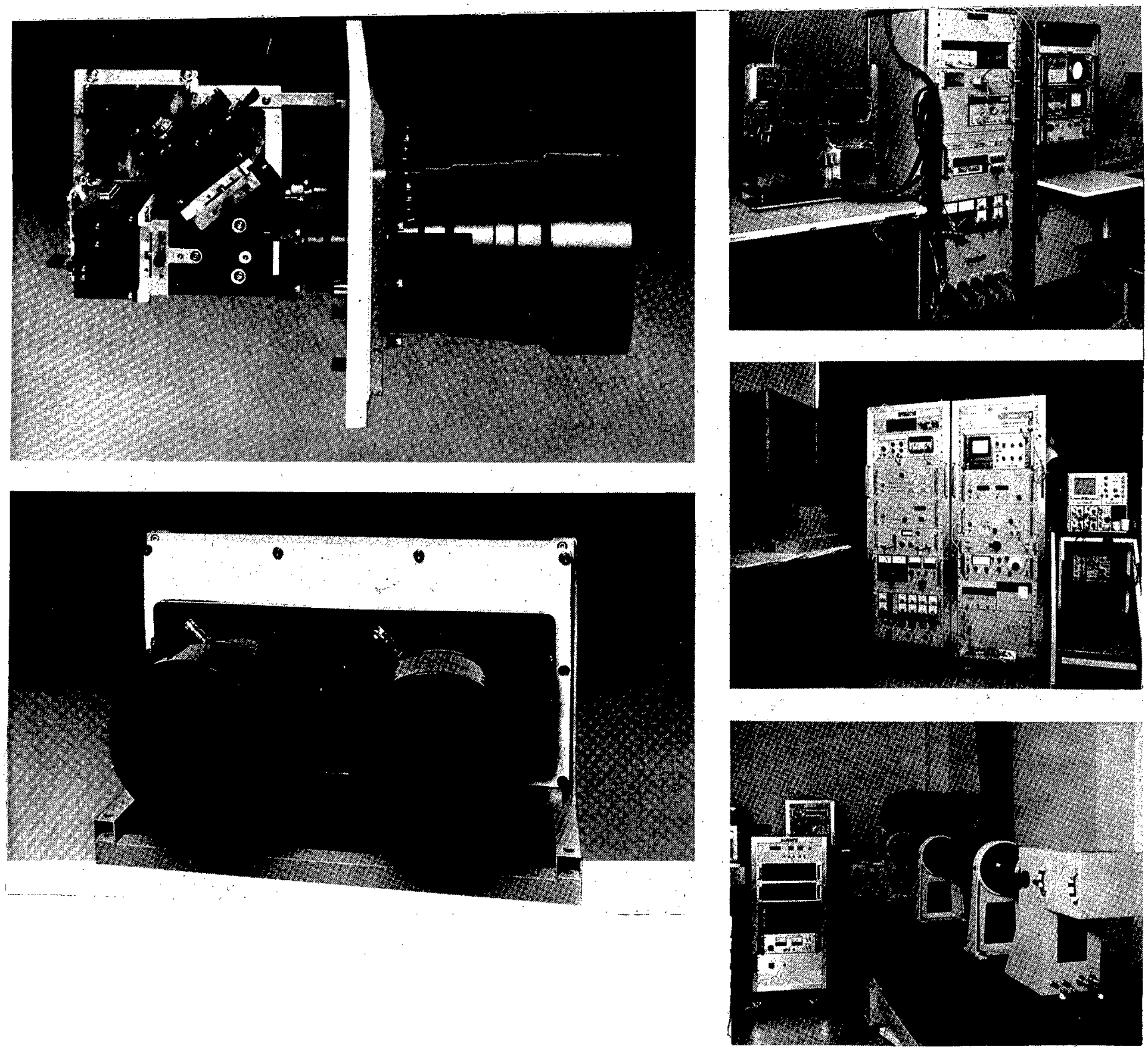
- DCS/SAR relay

The DCS/SAR relay receives UHF band signals from a ground station and reemits them in the L band. Basic experiments, such as determining the location of an object on the ground using the Doppler effect, are carried out using this relay.



Key:

1. Mission equipment charge
2. Visible near-infrared radiometer scanning radiometer section
3. Visible thermal infrared radiometer
4. Microwave parabola antenna
5. UHF quadrifilar helical antenna
6. Up[-link]
7. Antenna driver section
8. Circularly polarized wave feeder
9. Signal processing section
10. Sky horn
11. RF circuit section
12. Preselector
13. High speed data transmission section
14. Frequency converter section
15. Power amplifiers
16. 23 GHz band receiver (RF section)
17. 23 GHz band receiver (IF/detector section)
18. 31 GHz band receiver (RF section)
19. 31 GHz band receiver (IF/detector section)
20. DCS/SAR receiver
21. DCS/SAR transmitter
22. To X-band antenna
23. Signal processing section
24. Circularly polarized wave feeder
25. To signal synthesizer circuit
26. L-band quadrifilar helical antenna
27. Down[-link]



Upper, lower left: MESSR scanning radiometer section
Upper right: MESSR high speed data transmission section and the apparatus for performance evaluation
Middle right: MESSR signal processing section and the apparatus for performance evaluation
Lower right: Apparatus for a performance evaluation of the MESSR

Launch/Operation

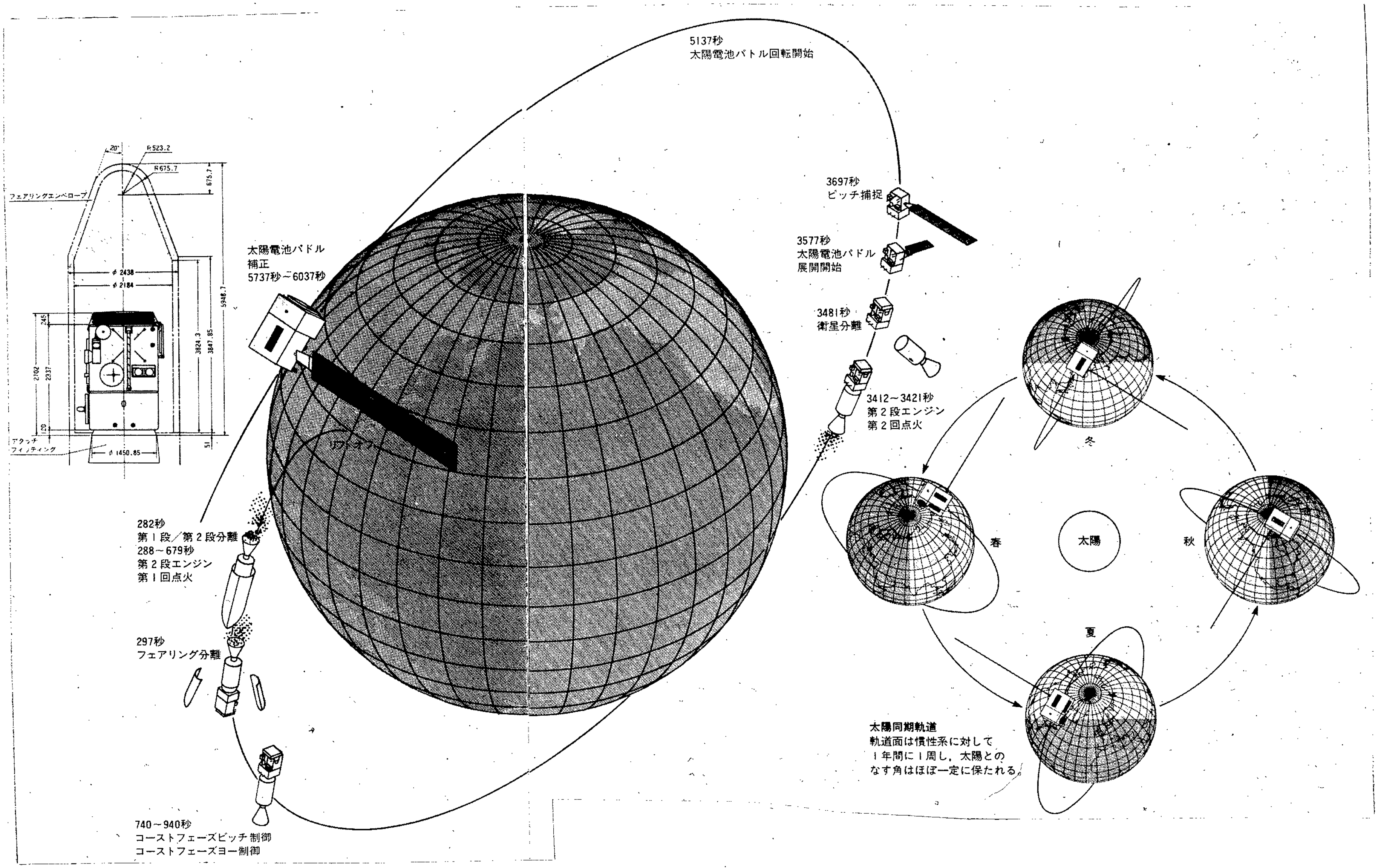
MOS-1 will be launched by the N-II launcher from the Tanegashima Space Center. When the satellite reaches an altitude of 913 km, its second stage points the attitude of the satellite for insertion into the planned orbit. The satellite will be separated from the launcher over South America, and it will be inserted into a solar synchronous, semi-recursive orbit. After damping the nutation, which may occur after separation, is confirmed, the solar cell paddle will be extended, the satellite's pitching axis will be arrested, the sun will be traced by the solar cell paddle, and then the satellite will begin to track the sun. Orbital insertion errors will be corrected by the gas jet system within a week. During launching and the initial stages, the Tsukuba Space Center will serve as the central tracking and control station. Tracking and control of the satellite will be carried out by the Masuda tracking and control station, which will serve as the main station, with the help of Katsuura, Okinawa, and a down-range station (in the Caroline Islands, on a ship, or in South America).

The attitude of a satellite in orbit is disturbed by solar radiation pressure, gravitational inclination, and residual magnetism. Maintenance of the attitude against external disturbances and unleading are all processed on board without interference from the ground stations. The external disturbances that affect the satellite's orbit are the gravitational forces of the moon and the sun, solar radiation pressure, and atmospheric resistance. The altitude is maintained within ±390m, and orbital corrections are carried out approximately every 300 days.

In stationary stages, housekeeping and stationkeeping are carried out by the Tsukuba Space Center through Masuda and Katsuura tracking stations and the Okinawa tracking and control station, which will serve as the main tracking station. Housekeeping data, which are collected during the time zones that cannot be observed directly from the Japanese stations, are recorded on the data recorder and then replayed in the visible time zone. The operation of mission equipment is controlled by the Earth Observation Center. Observed and telemetry data will be provided to overseas data receiving stations by using stored commands.

An example of the launch sequence

Elapsed time (seconds)	Events
0	Lift-off
282 (4 minutes 42 seconds)	Separation of the first and second stage
288 (4 minutes 48 seconds)	The first ignition of the second stage engine
297 (4 minutes 57 seconds)	Fairing separation
679 (11 minutes 19 seconds)	The first burning of the second stage engine completed (SECO 1)
3412 (56 minutes 52 seconds)	The second ignition of the second stage engine
3421 (57 minutes 1 second)	The second burning of the second stage engine stopped (SECO 2)
3481 (58 minutes 1 second)	Satellite separation
3577 (59 minutes 37 seconds)	Start extending the solar cell paddle
3697 (61 minutes 37 seconds)	Arrest pitching
5137 (85 minutes 37 seconds)	Start rotating the solar cell paddle
5737 (95 minutes 37 seconds)	Start corrections for the solar cell paddle
6037 (100 minutes 37 seconds)	Complete corrections for the solar cell paddle


5137秒
太陽電池パドル回転開始
3697秒
ピッチ捕捉
3577秒
太陽電池パドル
展開開始
3481秒
衛星分離
3412～3421秒
第２段エンジン
第２回点火
太陽電池パドル
補正
5737秒～6037秒
282秒
第１段／第２段分離
288～679秒
第２段エンジン
第１回点火
297秒
フェアリング分離
740～940秒
コーストフェーズピッチ制御
コーストフェーズヨー制御
フェアリングエンベロープ
アタッチ
フィッティング
冬
春
太陽
秋
夏
太陽同期軌道
軌道面は慣性系に対して
１年間に１周し，太陽との
なす角はほぼ一定に保たれる。

Key: [to page 52 figures]

[Figure in upper left corner]

1. Fairing envelope
2. Attach fitting

[Large globe figure in center--
starting in center of globe and moving
counterclockwise with line]

1. Lift-off
2. 282 seconds; the first and second stage separate; 288-679 seconds; the second stage engine is ignited for the first time
3. 297 seconds; fairing separates
4. 740-940 seconds; control pitching during the coast phase; control yawing during the coast phase
5. 3412-3421 seconds; the second stage engine is ignited for the second time
6. 3481 seconds; the satellite separates
7. 3577 seconds; extension of the solar cell paddle starts
8. 3697 seconds; pitching is arrested
9. 5137 seconds; the solar cell paddle begins to rotate
10. 5737-6037 seconds; corrections for the solar cell paddle are applied

[Global system on right]

Solar synchronous orbit; the orbital plane rotates once a year with respect to an inertial system, and the angle between the sun and the orbital plane is kept almost constant.

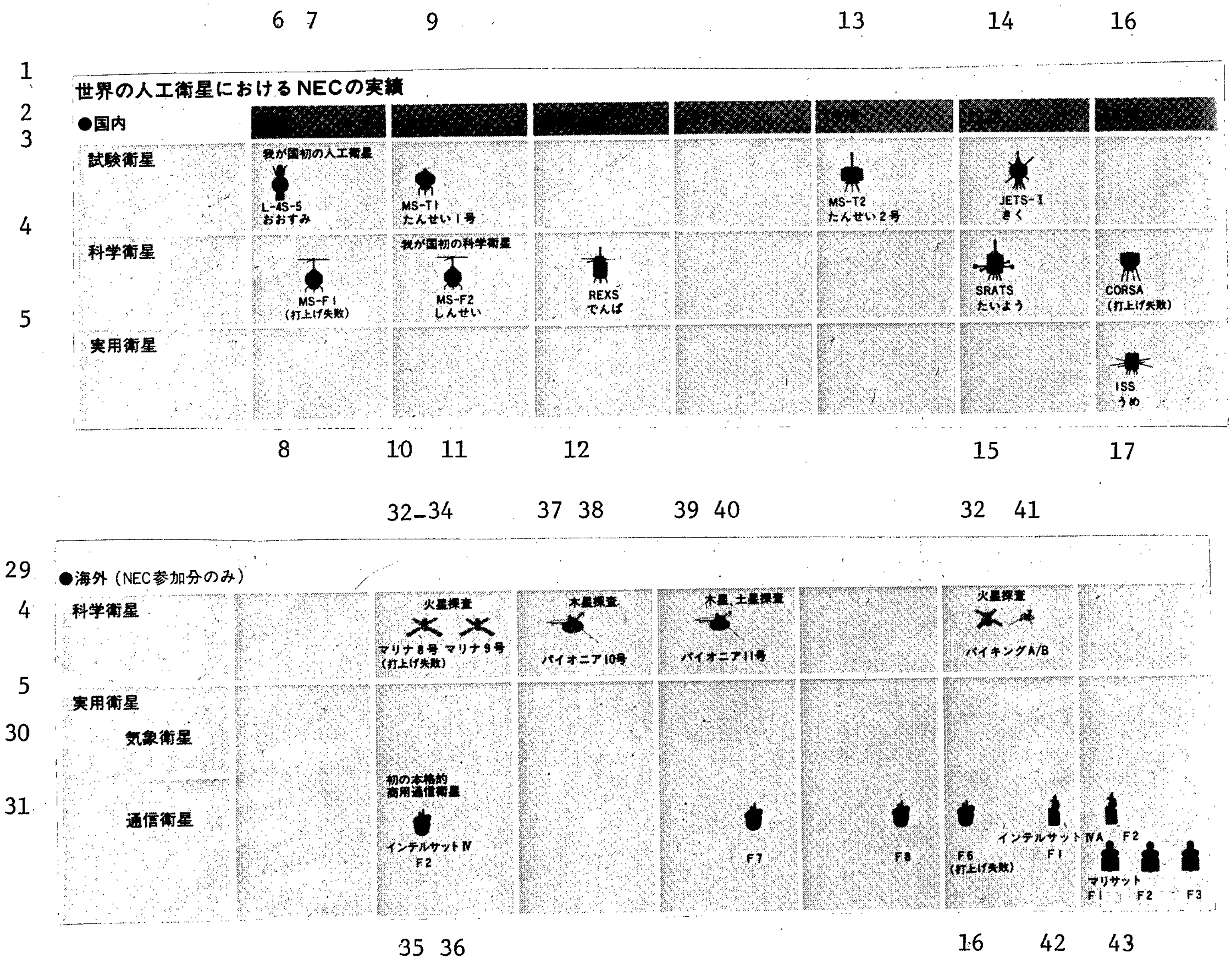
[center circle]	The sun
[north globe]	Winter
[east globe]	Fall
[south globe]	Summer
[west globe]	Spring

1 MOS-1 システム運用モード表

2 サブシステム ＼ 3 モード		4 打上げモード	5 初期捕捉モード	6 軌道上モード									
				7 不可視モード	8 日照モード							9 日陰モード	
					MESSR +VTIR +MSR	MESSR + VTIR	MESSR + MSR	VTIR + MSR	MESSR	VTIR	MSR	VTIR	MSR
10 ミッション機器	可視近赤外放射計(MESSR) 11				●	●	●		●				
	可視熱赤外放射計(VTIR) 12				●	●		●		●		●	
	マイクロ波放射計(MSR) 13				●		●	●			●		●
	DCS/SAR 中継器 14			●	●	●	●	●	●	●	●	●	●
15 バス機器	通信系/アンテナ系 16												
	VHF 送信機 17	●	●										
	VHF 受信機 / UHF アンテナ 18	●	●	●	●	●	●	●	●	●	●	●	●
	Sバンド送信機 / Sバンドダウンリンクアンテナ 19	●	●	●	●	●	●	●	●	●	●	●	●
	Sバンド受信機 / Sバンドアップリンクアンテナ 20	●	●	●	●	●	●	●	●	●	●	●	●
	Sバンドトランジションアンテナ 21	●*1	●*1	●	●	●	●	●	●	●	●	●	●
	USB 送信機 / USB アンテナ 22				●		●	●			●		●
	太陽電池パドル系 23		●	●	●	●	●	●	●	●	●	●	●
	ガスジェット系 24		●	← 軌道補正のため1年に数回使用 26 →									
	姿勢軌道制御系 / テレメトリ・コマンド系 / 電源系 / 熱制御系 25	●	●	●	●	●	●	●	●	●	●	●	●

●：使用するサブシステムあるいは機器 27
*1：送・受信用(他は受信用として用いる) 28

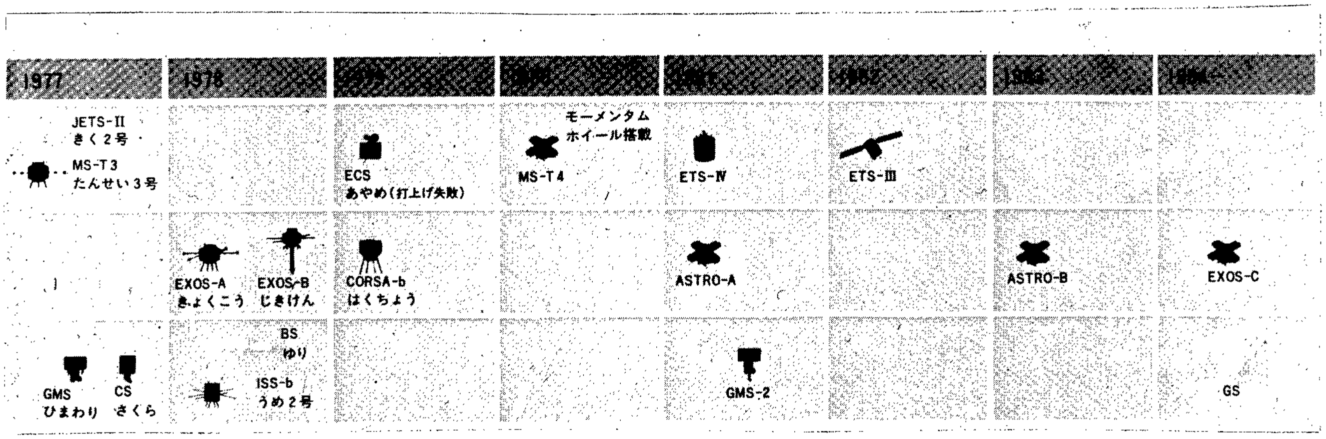
Key:
1. Table of system operating modes for MOS-1
2. Subsystem
3. Mode
4. Launch mode
5. Early arrest mode
6. In-orbit mode
7. Invisible mode
8. In-the-sun mode
9. In-the-shade mode
10. Mission equipment
11. Visible near-infrared radiometer (MESSR)
12. Visible thermal infrared radiometer (VTIR)
13. Microwave radiometer (MSR)
14. DCS/SAR relay
15. Bus equipment
16. Communication and antenna systems
17. VHF transmitter
18. VHF receiver; UHF antenna
19. S-band transmitter; S-band down-link antenna
20. S-band receiver; S-band up-link antenna
21. S-band transition antenna
22. USB transmitter; USB antenna
23. Solar cell paddle system
24. Gas jet system
25. Attitude orbit control system; telemetry/command system; power supply system; thermal control system
26. Used several times a year to correct the orbit
27. ●: Subsystem or equipment used
28. *: For both transmitting and receiving (others are for receiving only)



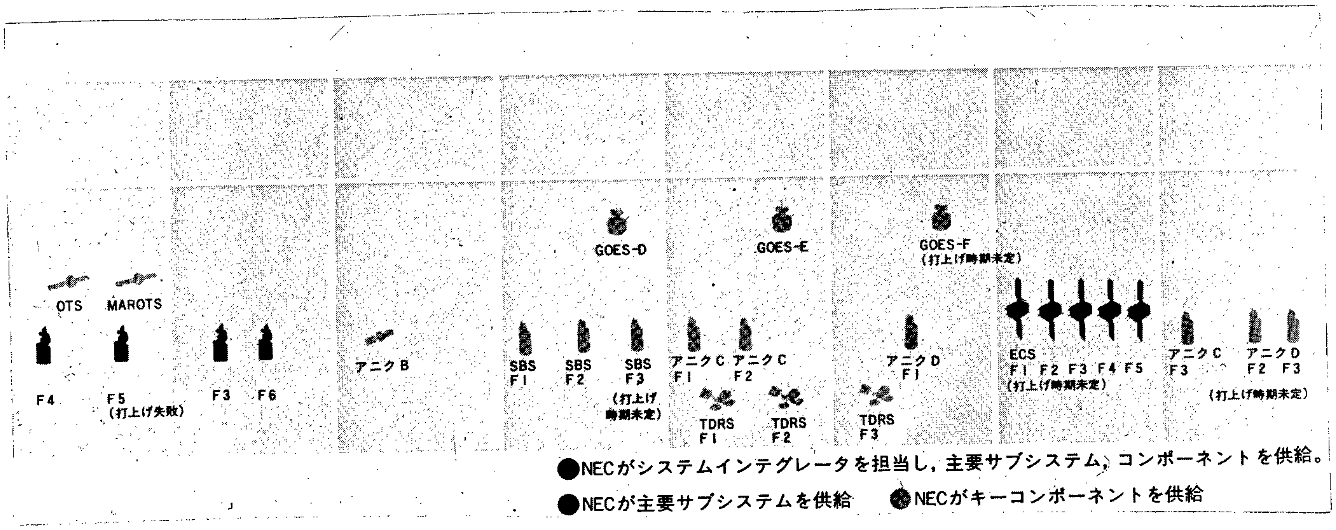
Key:

1. Worldwide achievements of NEC in artificial satellites
2. Domestic
3. Experimental satellites
4. Scientific satellites
5. Satellites for practical applications
6. First artificial satellite of Japan
7. Osumi
8. (Launch failed)
9. Tansei No 1
10. First Japanese scientific satellite
11. Shinsei
12. Dempa
13. Tansei No 2
14. Kiku
15. Taiyo
16. (Launch failed)
17. Ume
18. Kiku No 2
19. Tansei No 3
20. Himawari
21. Sakura
22. Kyokko
23. Jikiken
24. Yuri
25. Ume No 2
26. Ayame (launch failed)
27. Hakucho
28. Momentum wheel installed onboard
29. Overseas (only those in which NEC participated)

18 19 22 23 26 28



20 21 24 25 27



16 44 45 44 44 45 44 45

30. Meteorological satellites
31. Communications satellites
32. Mars exploration
33. Mariner No 8 (launch failed)
34. Mariner No 9
35. First full-scale commercial communications satellite
36. Intelsat IV
37. Jupiter exploration
38. Pioneer No 10
39. Jupiter and Saturn exploration
40. Pioneer No 11
41. Viking A/B
42. Intelsat IV A
43. Marisat
44. Anik
45. (Launch date undecided)

- NEC took the role of a system integrator, and provided major subsystems and components
- NEC supplied major subsystems
- NEC provided key components

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

	分類	項目	おおすみ	たんせい	INT.IVF2 F6～F8	しんせい	でんぱ	たんせい2	たいよう	きく	うめ	INT.IVA F1～6	たんせい3	ひまわり	さくら	きょっこう	うめ2	じきけん	はくちょう	あやめ	MS-T4	ASTRO-A	GMS-2	ETS-III
18 19	システム技術	プログラム管理	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	○	○	○	○	△	○
20		システム設計	○	○		○	○	○	○	○			○	△		○		○	○		○	○	△	
21		システムインテグレーション試験	○	○		○	○	○	○	○			○	△		○		○	○		○	○	△	
22 23	共通サブシステム技術	インテグレーションハードウェア	○	○		○	○	○	○	○			○	△		○		○	○		○	○	△	
24		構造系ハードウェア	○	○		○	○	○	○	○			○	△		○		○	○		○	○	△	
25		熱制御系ハードウェア	○	○		○	○	○	○	○			○	△		○		○	○		○	○	△	
26		通信系ハードウェア	○	○		○	○	○	○	○	○		○	△		○	○	○	○		○	○	△	
27		電源系ハードウェア	○	○		○	○	○	○	○	○		○	△		○	○	○	○		○	○	△	
28		姿勢軌道制御系ハードウェア	○	○		○	○	○	○	○	○		○	△		○	○	○	○		○	○	△	○
29		オンボードプロセッサ		○		○	○	○	○	○			○	△		○		○	○		○	○	△	
30 31	ミッションサブシステム技術	ミッション系ハードウェア						○					○	△/○							○		△/○	○
32		通信／データ処理系ハードウェア			○							○		△	○					○				
33 34	支援技術	地上支援装置	○	○		○	○	○	○	○	○		○	△	○	○	○	○	○	○	○	○	△	○
35		地上施設／設備	○	○		○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	
36		打上げ支援作業	○	○		○	○	○	○	○			○	△		○		○	○		○	○	○	
37		運用支援作業	○	○		○	○	○	○	○			○	△		○		○	○		○	○	○	
38		解析／評価作業	○	○		○	○	○	○	○			○	△		○		○	○		○	○	○	

○：自主 △：外国と協力

39 40

Key:

1. Osumi
2. Tansei
3. Intelsat IV F2, F6-Fi
4. Shinsei
5. Dempa
6. Tansei No 2
7. Taiyo
8. Kiku
9. Ume
10. Tansei No 3
11. Himawari
12. Sakura
13. Kyokko
14. Ume No 2
15. Jikiken
16. Hakucho
17. Ayame
18. Systems engineering
19. Program management
20. System design
21. System integration testing
22. Common subsystems engineering
23. Integration hardware
24. Airframe system hardware
25. Thermal control system hardware
26. Communications system hardware
27. Power supply system hardware
28. Attitude orbit control system hardware
29. Onboard processor
30. Mission system subsystem engineering
31. Mission system hardware
32. Communication/data processing system hardware
33. Support engineering
34. Ground support apparatus
35. Ground facilities/installations
36. Launch support operations
37. Operation support tasks
38. Analysis/evaluation operations
39. By ourselves
40. In cooperation with foreign firms

[Back cover]

NEC: Nippon Electric Company, Ltd.

Main office

33-1 Shiba 5-chome, Minato-ku, Tokyo, (Headquarters building of NEC)

Telephone: Tokyo (03) 454-1111 (key number) Postal code: 108
Space Development Project, Yokohama Establishment
4035 Ikebe-cho, Midori-ku, Yokohama, Kanagawa Prefecture
Telephone: Yokohama (045) 932-1111 (key number) Postal code: 226
October 1979

9829
CSO: 8129/0238

- END -